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THREE LARGE CANTILEVER BRIDGES are to be commenced during the present year. The largest of these will be the bridge over the Mississippi River at Thebes, Ill., and Gray's Point, Mo., connecting the Chicago & Eastern Illinois R. R. with the St. Louis & Southwestern Ry., which at present exchange traffic by a car ferry. The channel span will be 671 ft. c. to c. of piers, with anchor arms of 520 ft. 2 ins. on the east and 521 ft. 2 ins. at the west. Shore spans of 320 ft. at the east and 518 ft. 6 ins. at the west will connect the 600 ft. approaches, consisting of 45-ft. and 50-ft. concrete arches. It will be a double-track structure with a headway of 65 ft. above high water. The bridge will be built by the Illinois & Missouri Bridge Co., of which Mr. Alfred Noble and Mr. Ralph Modjeski, Mems. Am. Soc. C. E., are the engineers. The Wabash R. R. will carry its new Pittsburg extension into that city by a bridge over the Monongahela River, with a channel span of 812 ft. c. to c. of piers, with two anchor arms of 346 ft. The cantilever arms of the channel span are 220 ft. long, and the suspended span 360 ft. The same road will cross the Ohio River at Mingo Junction, O., by a very similar bridge, with a channel span of 700 ft., and anchor arms 290 ft. long. The American Bridge Co. has the contract for the superstructures of both bridges. They were designed by Boller & Hodge, of New York, and will both be double-track structures. Mr. J. W. Patterson, of Pittsburg, Pa., is Chief Engineer of the Pittsburg, Carnegie & Western R. R. and Pittsburg, Toledo & Western R. R., which form the Pennsylvania and Ohio parts of the new Wabash line.

A HIGH CONCRETE ARCH is to be built this season near Danville, Ill., to carry the Peoria Division of the "Big Four" R. R. over the North Fork of the Vermilion River. The railway is about 85 ft. above the bed of the river and it is stated that the arch will have a span of some 200 ft.

THE CAISSON FOR THE BROOKLYN TOWER of the Third East River Bridge was towed from the construction yard at 151st St. and the Harlem River to its location at the foot of Washington St., Brooklyn, on March 17, and work is now in progress preparatory to the sinking. This caisson is of wood, 144 × 78 ft. in plan and 56.29 ft. deep. It will be surmounted by masonry tower foundations 58.21 ft. high, which will carry a steel tower 325 ft. high.

CONTRACTS FOR THE ST. LOUIS EXHIBITION of 1903 have already been placed as follows, all the firms being located in St. Louis, Mo.: 1, electricity and machinery building, Wm. Goldie & Sons Co., 604 Fullerton Building; 2, textiles building, Dunnavant & Estel, Fullerton Building; 3, varied industries building, Rountree Construction Co., Mermod & Jaccard Building; 4, main trunk sewers, Hanley-Casey Co., exhibition grounds; 5, hand sewers, McIntyre & Teese, 5478 Easton Ave.; 6, waterway for changing the course of the Des Peres River, Rich Construction Co., 710 Roe Building.

A NEW UNION RAILWAY STATION at Washington, D. C., is to be built at a cost of $5,000,000. The new station will be constructed of white marble and have a frontage of 700 ft. It will be located some distance northeast of the present Baltimore & Ohio R. R. station, and the various railways will connect through a tunnel under Capitol Hill and enter the station by a viaduct and elevated tracks. All grade crossings will be abolished.

FOG SIGNAL EXPERIMENTS have been conducted for some time under the auspices of the English, Irish and Scottish light-house boards at St. Catherine's Point, on the Isle of Wight, with Lord Rayleigh as the chief scientific adviser. As a result of these experiments they found a low pitch best; and a siren with 98 vibrations to the second emitted a sound easily heard at more than 20 miles off the coast on calm days. Under the same conditions a siren of higher pitch was only heard 10 miles. With wind blowing in the wrong direction and a noisy sea, the low pitch only carried two miles, and the high pitch carried a little further. As already known to the American light-house authorities, belts of silence were found not far from the fog-horn, with the sound audible beyond. Prof. Tyndall, 27 years ago, explained this silence as due to the interference of the sound waves issuing directly from the instrument with another set striking the surface of the water and being reflected upwards. The late experimenters obtained little new light on this condition and found no remedy for it. The commission approves of a lately introduced trumpet, which is adjusted to point upwards, and has an inverted cone of metal placed centrally over the mouth in such manner that the sound waves are deflected and flow out horizontally on all sides.

DALNY, THE NEW RUSSIAN COMMERCIAL PORT in North China, says U. S. Consul H. B. Miller, of Ninchwang, is on Talienwan Bay, on the eastern side of the Liaotung Peninsula, and 45 miles from Port Arthur. This harbor is free from ice and will admit ships of 30-ft. draft at low water, with a 12-ft. rise of tide. The Russians are now constructing five large stone and concrete piers, from 60 to 100 ft. wide and 1,700 to 2,600 ft. long. On these piers will be railways, warehouses, elevators, etc. One of these piers was finished in July, 1901, and another will be ready this year. Two first-class dry-docks are also being built, capable of taking the largest warships. This port is to be absolutely free.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision on the Pittsburg, Ft. Wayne & Chicago Ry., near Youngstown, O., on March 24. Four men were killed, it is reported, and a number of others injured. There was a heavy fog at the time of the wreck, but no direct cause for the collision is known.——On March 23 a northbound vestibuled limited train on the Southern Ry. ran into an obstruction produced by a landslide near Charlottesville, Va. Two men were killed and several dangerously injured. The wreck took fire and most of the contents of the mail car were destroyed.

THE PITTSBURG FILTRATION CONTRACT DECISION, noted in our issue of March 20, will not be appealed from by the city. This is the decision of Mr. J. O. Brown, City Recorder (virtually mayor). Mr. Brown has issued an order for the preparation of complete plans and estimates for all the contemplated water supply improvements, to comply with the requirements of the charter, as laid down by the court.

A ROCK SLIDE in the New York Rapid Transit tunnel on March 21, in the neighborhood of 37th St. and Park Ave., resulted in the wrecking of several residences, the necessary shoring-up of other houses, and the filling in of the tunnel excavation on that side of Park Ave. for a considerable distance. The cause of the slip was the presence of a seam in the rock extending at an angle of about 45° from the tunnel to and under the foundation of the houses effected. It is stated that the rock penetrated by the tunnel, to that point, was solid in appearance, and the presence of the mischief-making fissure was unknown until the damage was done. The existence of springs in the soil near 38th St. may have aggravated the trouble. The residents of that section lay the blame for the accident upon the Rapid Transit Commission for locating that edge of the tunnel only 8 ft. outside the building line, instead of 20 ft. as was generally supposed by the property owners when they examined the original plans. But as the Commission has authority to change the plans at any time, this objection does not hold good. The danger-zone lies between 36th and 39th Sts.; and while the accident will cost money for damages and some delay in completing the tunnel through this section, the cause of the trouble is of a kind that could hardly have been foreseen or guarded against in underground work.

THE ESTIMATES for the Street Cleaning Department of Greater New York for the current year make a grand total of $5,464,612. This includes the collection, removal and final disposition of garbage, ashes and rubbish, as well as street cleaning proper and disposal of the sweepings.

BIDS FOR GARBAGE DISPOSAL in the borough of Brooklyn, New York city, will be received by the Department of Street Cleaning on April 15. The contract will be for five years from Sept. 1, 1902. The contractor must have a plant capable of handling 650 tons a day. The average daily amount to be handled is 300 tons. The contractor is to provide dumping places, receive, remove and finally dispose in a sanitary manner all the garbage collected by the city or by authorized collectors. The city reserves the option of buying the plant at the expiration of the contract. Mr. John McG. Woodbury is Commissioner of Street Cleaning, with offices at 13 Park Row, New York City.

THE "ENGINEERS' CLOSE PROFESSION BILL," which was designed to restrict the practice of civil engineering in Ontario and on which we commented last week, has been rejected by the Ontario legislature.

THE PACIFIC COAST OIL CO., or the Standard Oil Co. practically, is to build 276 miles of 8-in. pipe line, extending from Bakersfield to Point Richmond, on San Francisco Bay. Owing to the slight grades, pumping stations will be necessary. Mr. Forrest M. Towl, M. Am. Soc. C. E., and Engineer of the National Transit Co., 26 Broadway, New York, is also engineer of this new pipe line.

THE RE-GRASSING OF WASTED CATTLE RANGES in Nebraska, Wyoming, Colorado, Utah, Montana, Idaho and the Dakotas is to be attempted by the railways penetrating these States, according to a Minneapolis report to the New York "Times." The first problem to be solved is the finding of a grass plant which will be suitable for stock purposes, and to this end 3,000 or 4,000 acres is to be fenced off and divided into 30 smaller plots for experiments in planting. The work will be in charge of Mr. R. C. Judson, Industrial Agent for the Oregon Railway & Navigation Co. These Western cattle ranges have been ruined by too much crowding and by sheep. The latter especially, if too much bunched, soon destroy every growth except sage brush with their sharp teeth and equally sharp hoofs. It is expected that once the feasibility of re-grassing is proven, the Federal and State governments will lend their aid to the movement.

ELECTRIC TRACTION AS A SUBSTITUTE for steam has been introduced upon about 81 miles of railways in Lombardy, Italy. These lines traverse the picturesque North Italian lake regions, and as the country is mountainous and water power abundant, there are special economic advantages in the use of electric power.

STEAM MOTOR-CARS, according to a British Board of Trade report, are being used in Belgium and other places in Europe, on branch lines with little traffic, on trunk lines for local traffic, and in industrial centers and city suburbs. On the Belgian State Railways the motor-cars used are 46 ft. long, weigh 50 tons, and can carry 53 passengers. They run at speeds of 18½ to 34 miles per hour, and require the services of 2 to 3 men. The Rowan motor cars used in the suburbs of Antwerp have 46 seats for passengers, and attain a speed of 31 miles per hour. The same vehicle is used by the Paris Omnibus Co. The Russian State Railway has two steam motor-cars; these are double-decked and carry 20 first, 20 second and 40 third-class passengers. They burn naphtha, require three men to operate them and have a maximum speed of 14 mile per hour. The Northern Railway of France operates a steam motor-car for postal service, and carrying 12 passengers. The same company is trying a storage battery motor-car, weighing 20 tons, carrying 12 passengers, and making a speed of 30 miles per hour. It will run 74 miles without recharging.

UNDERGROUND WATER RIGHTS IN MISSISSIPPI have been declared by the Supreme Court of that state to pertain absolutely to the owner of the soil, where no well-defined flow through underground channels can be established. In the case under judgment an air-lift plant, it was alleged by the Board of Supervisors of Clarke county, depleted the water in a county well. We are indebted to Mr. Walter G. Fitzpatrick, M. Am. Soc. C. E., of Jackson, Miss., for the information on which this note is based.

A NEW DESIGN OF CONCRETE-STEEL RETAINING WALL.

We illustrate in the accompanying cuts a general view and some of the principal details of a new form of concrete-steel retaining wall construction, which has been patented by Mr. Frank A. Bone, Civil Engineer, of Lebanon, O. The particular work to which the illustrations refer (Fig. 1) is a Melan concrete-steel arch of 24 ft. span erected during the summer of 1901 near Black Lick, O. The wing walls of this arch vary from 20 ft. to 60 ft. in length and from 10 ft. to 28 ft. in height and are of the concrete-steel design, which is illustrated by Fig. 2. This wall construction is described as follows in a letter to us from the inventor:

Fig. 2 is a cross-section of the wall where it is

Fig. 1. Melan Concrete-Steel Arch at Black Lick, O., Having Bone Concrete-Steel Wing Walls.

Oregonia Bridge Co., Oregonia, O., Contractors.

24 ft. 8 ins. in height, showing it as it was constructed. The masonry of the wall was of concrete of the proportions of 1¼ barrels of cement, ½ cu. yd. of sand, and 1 cu. yd. of crushed limestone, with one-third of the whole volume of large-sized sound freestone embedded in the concrete. The walls have a coat of plaster on each side.

The steel bents shown embedded in the back part of the wall were composed of plates and angles; were placed 4 ft. apart throughout the wall, and were connected together at the bottom with 2 × 2-in. angle. The bents were figured strong enough to sustain safely the entire tensile strain in the wall at the different points; all the tensile strength of the concrete being allowed to go to increase the margin of safety. Small angle brackets were riveted to the bents at short intervals to prevent any tendency of the bents to slide through the concrete. It will be noticed that the size of the upright member increases as it descends the wall, corresponding to the increase of strains. The plate in this member also acts to prevent bulging or shearing of the wall.

The ¼ × 4-in. plate extending diagonally downward toward the toe of the wall is an anchor to prevent any upward or backward movement of the metal at that point resulting from the strains to which the bent is subjected. This anchor plate is twisted one-fourth way round at its lower end, bringing the edge to the observer. The plate extending down along the heel is twisted one-quarter way round in a like manner.

A novel form of mold or casing was used for the back part of the wall, as shown in Fig. 3, by overlapping the sheeting to form the steps shown. These steps are for the purpose of creating friction between the wall and the material retained.

The foundation of the wall is on solid rock. The contractors for the bridge were the Oregonia Bridge Co., of Oregonia, O.

The principal advantages claimed for this construction is that the weight of the retained material resting on the heel is used as a force to keep the wall in its normally upright position, and that metal is used where and only where the greatest tensile strains come. The front part of any good masonry wall is sufficient to bear the compressive strains. With the use of steel the wall may be made much lighter in the vertical part and the base may be made much wider in proportion, without danger of breaking off. The whole amount of masonry required is from 30 to 40% less than in an ordinary-shaped retaining wall, to be amply safe against overturning, bulging, settling or sliding on the base. With the toe of the wall resting on a firm foundation it is evident that the wall, to be overturned by the pressure of the earth from behind, must rise upward in the back part together with the material resting on the heel that projects back of the vertical part of the wall. Therefore, the weight of the earth on and vertically above the projecting heel multiplied by its distance from the fulcrum at the toe gives the moment of the resistance to the overturning of the wall, exerted by the earth resting on said heel. To prove the truth of the above theory the inventor made numbers of experiments with model walls of similar shape to Fig. 2 with dry sand as the retained material, and found the results of the experiments to agree well with the theory.

More recent designs of this wall use plates slightly corrugated for the entire steel bent, thus dispensing with the small brackets on the sides of the bent, and where timber foundations are used the bents are connected to them at the back part of the heel.

CONSTRUCTION AND OPERATION OF AN ELECTRIC INTERURBAN RAILWAY.

At the meeting of the Chicago Electrical Association on March 17 a paper was presented on "The Grand Rapids, Holland & Lake Michigan Rapid Ry. Its authors were Mr. George A. Damon (Managing Engineer of the Arnold Electric Power Station Co., of Chicago), and Mr. William D. Ray (Consulting Mechanical and Electrical Engineer, of Detroit). While this railway is but one of a very large number of electric interurban railways now being built, it presents some particular features of interest which we describe below, the portions printed in smaller type being quoted direct from Mr. Damon's paper.

The road proper is 26 miles long, extending from Grand Rapids to Holland, where it connects with the Holland & Lake Michigan Ry. and the Saugatuck, Douglas & Lake Shore Ry., which reach a large number of summer resorts and also pass through an extensive fruit belt. These two latter electric lines aggregate 19 miles in length, all built on private right of way, with the exception of three miles in villages.

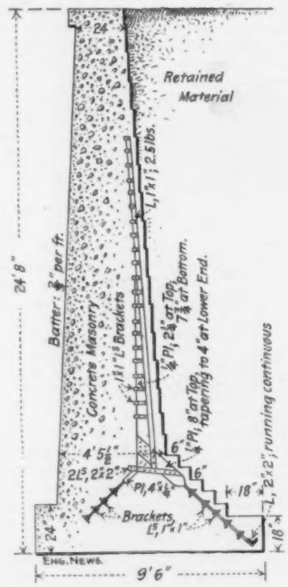


Fig. 2. Section Showing Construction of Bone Concrete-Steel Wing Walls for Black Lick Bridge.

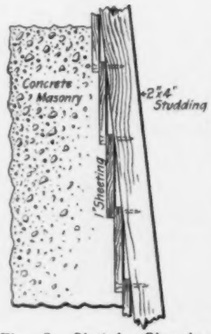


Fig. 3. Sketch Showing Construction of Mold to Form Steps in Back of Bone Concrete-Steel Retaining Wall.

The road is in rolling country, with some steep hills, and has several timber trestles spanning creeks. Its private right of way is 66 ft. wide, and is fenced in; cattle guards and signs are placed at all road crossings. Grade crossings of steam railway main tracks were prohibited, and there are two subways with concrete abutments carrying plate-girder spans. [illegible] crossings of spurs and side tracks were permitted when protected by derailing devices in the electric tracks. The biggest bank is about [illegible] ft. long and 42 ft. high. A sink-hole about [illegible] ft. wide was encountered on a marsh near Holland and after the road had been graded and the track laid the track and bank disappeared, leaving a pond of water. After vain attempts to fill the hole, a pile trestle was built, 30-ft. piles [illegible] spliced together. It is expected that additional work will be required at this point. A view of this sink-hole, after the disappearance of the track, is shown in Fig. 1.

The line is double track, standard gage, with 70 and 67-lb. T-rails on cedar ties 24 ins. to c.; oak ties are used at switches. Gravel [illegible] last is used, and the roadbed is drained where necessary by vitrified tile 12 to 36 ins. diameter. The sharpest curve is 6°, and the maximum grades are 3% at the Holland subway and 3.5% on the rest of the line. There are loops at all terminals and Ys at the two car sheds and the Zeeland substation.

The bonding of the rail joints was done very thoroughly. Two types of bonds were installed: a foot bond on the leaving rail where angle bars did not permit the usual web bond, and on all new rail a web bond. These bonds were No. 0000, 6 ins. long and crimped to 5 ins. between centers, of the "Protected" type furnished by the J. M. Atkinson Co. The drilling of rails for receiving bonds was done by a special machine which consists of a gasoline engine, tank and batteries, transmission and speed regulating devices, mounted on a special car equipped with drill stocks. This outfit paid for itself many times over in the saving effected. The engine gave but little trouble and the outfit worked satisfactorily, requiring only one mechanic for both engine and drills. A combination drill was used, which not only drilled the foot of the rail, but also countersunk the hole. A screw compressor, operated by two men, was used in compressing bonds. The rail circuit was cross-connected at every twelfth pole by a No. 0 tinned copper wire, and connected with a good ground; all switches and frogs were well bonded and cross-connected. Where the tracks crossed a creek, the rail circuit was grounded by sinking a metal plate into the flowing water below.

Stations in the small villages and shelters at road crossings have been placed where warranted by the traffic. The substation buildings at Zeeland and Macatawa are each combined with a waiting room and freight office. The attendant for the electrical machinery looks after the selling of tickets, handling of freight, etc.

The power station is at Jenison, and at present contains only two generating units, or half the equipment required for the operation of the road to its full capacity. The steel roof trusses carry a comparatively flat roof, sloping ⅝-in. in 12 ins., and neither the engine room nor boiler room has a monitor roof, ventilation being provided by 36-in. Star ventilators. The floors and foundations are of concrete. In the engine room is a 15-ton electric traveling crane of 45 ft. span. Slack coal is used for fuel, and an electric traveling coal carrier is to be put in later to feed the furnace hoppers. The four boilers are of the Cahall horizontal type, built by the Aultman & Taylor Co., of Mansfield, O. Each has 2,650 sq. ft. of heating surface, and is rated at 10 sq. ft. of heating surface per horse power. Chain grates are used, made by the Green Engineering Co., of Chicago, and have 53 sq. ft. of grate surface, or 5 HP. of boiler per sq. ft. of grate. The ash pit holds the ashes for a 24-hour run. An economizer plant is to be put in later, but at present the smoke and gases are carried (without turns or bends) to a Sturtevant induced draft fan 9 ft. diameter and 4 ft. wide, which discharges into a short steel chimney 5 ft. diameter, mounted directly over the fan outlet. The top of the chimney is 40 ft. above the grates. The fan ordinarily runs at 100 revolutions per minute, but is regulated automatically by the pressure in the main steam header, the fan being speeded up if the pressure falls owing to a de-

mand for more steam. This mechanical draft equipment cost less than a steel chimney.

There are two Ball & Wood cross-compound Corliss vertical engines, rated at 750 HP. each, under a speed of 150 revolutions per minute, with 150 lbs. steam pressure. The cylinders are 21½ × 24 and 45 × 24 ins., and between the cranks is a flywheel weighing 16,000 lbs. The cylinders are steam jacketed, and between them is a reheating receiver. The exhaust passes down through the floor to a Deane jet condenser.

Both engines and generators are of the direct-connected type, but the method of connection departs somewhat from standard practice. The engine shaft extends beyond the main bearings a distance sufficient to receive the hub of a flanged coupling. The revolving fields of the generators are carried on an independent shaft resting in two adjustable bearings through which the generator shaft extends to receive the other half of the flanged coupling. The halves of the couplings on the engine and on the generator are thus in position to be connected by means of three taper bolts. In this way the generators are built and installed entirely independent of the engines without the usual delay resulting in an effort to secure co-operation between the engine and generator builders. The generators being independent of the engines it is possible to shift the generators from one engine to another in case of accident to either the engines or the generators. This arrangement gives a certain amount of reliability greater than is found with the ordinary independent unit plan, in which the breaking down of an engine or generator cripples the entire unit.

The connecting system described has proved to be particularly fortunate for this plant, as it developed in buying the electrical equipment that it would be impossible to secure shipment of the generators inside of eight months, whereas the road itself would be ready to operate inside of five months. To overcome this difficulty the engines were installed without waiting for the permanent generators, and a temporary belt pulley on an independent shaft was put in place in the bearings of one of the generators, a belt being run through a window to a belted double-current generator installed in a shed.

The Westinghouse alternators are of the three-phase, 25-cycle rotary field stationary armature type, of 500-K-W. capacity, and are provided with armature sliding frame to permit access to all windings for repairs without requiring the use of a crane. They have 20 poles and operate at a speed of 150 revolutions. The rating is 722 amperes per terminal. The two exciter dynamos are 125 volt 30-K-W. each and either is sufficient for supplying full field current for the two alternators. The separately excited fields require 120 amperes at 100 volts at full-rated current output per terminal, at 380 volts, working on 100% power factor. With an 80% power factor, on full load, an increase of 20% in field current is required. The alternator armatures are star connected and of the slotted drum type. The direct-current exciter generators are direct connected to horizontal simple engines running at 300 revolutions. These exciters are set on concrete foundations, built directly on the floor beams, so that no space is taken up in the basement by auxiliary foundations. The exciters and draft fan engine are located on a level and in the same part of the plant, thus reducing the work of the operator to a minimum.

The step-up static transformers, which are located in a gallery, are of the Westinghouse oil-cooled type, and are seven in number (two sets of three each and one spare), each being of 200-K-W. capacity. The ratio of conversion is one to fifty. Two 300-K-W. rotary converters are installed in the power house, for handling the sections of the line adjacent to the power house. The rotaries are started by an induction motor direct connected to the armature shaft and synchronized by means of lamps connected on one side to bus bars and on the other to the alternating current side of the rotaries. The switch controlling the starting motor is of the double-throw type, arranged for high and low voltage connections to transformers. Consequently, with one position of the switch the motor develops a speed slightly in excess of the synchronous speed and with the other position, a speed below it. This permits of the proper speed being reached as indicated by the synchronizing lamps. Each governor arm of the 750-HP. engine driving the alternator, is equipped with a series wound ¼-HP., 125-volt, Sprague electric motor, for controlling the speed of the engine in synchronizing generators. The control of this motor is from special switches and rheostats on the switchboard.

Six aluminum wires of 52,630 circular mils each leave the Jenison power house, carrying current at 20,000 volts, and follow along the railway tracks easterly to the Zeeland substation, 15 miles distant, and at this substation, these six wires pass through the building and continue on to Macatawa substation 10½ miles from Zeeland. The six high potential wires comprise two circuits. Although one circuit would suffice for the operation of the two substations, it was deemed best to split or divide the three conductors of the 105,500 c. m. of aluminum required, into six wires of 52,630 c. m. each, allowing both circuits to be normally run in multiple. In the event of accident by grounding or the breaking of a single wire or wires of one circuit, the other is in readiness to carry the load. Although effecting a greater drop in voltage by this makeshift, the cars would be kept in continuous operation with speed slightly impaired. Other combinations of the three-wire circuits are as follows:

Of the two alternators installed at the Jenison power house, one may deliver curent over one circuit to the Zeeland substation, and the other alternator over the second circuit, may operate the Macatawa substation, or circuits and substations may be put in multiple with the alternators. Again one of the circuits can be made inoperative or dead, between the power house and Zeeland, and the multiple combination continue between Zeeland and Macatawa or vice versa. This arrangement permits of great flexibility, with but comparatively slight increased cost.

The two, three-wire three-phase, alternating current circuits have the wires 24 ins. apart, at the corners of an equilateral triangle. All joints on these circuits are made with McIntyre connectors and the joint has been found very satisfactory. High tension wires are tied to Provo glass insulators, weighing 6 lbs. each, with a diameter across the base of 7½ ins. The bottom of the insulator is fully 5 ins. above the crossarm. Glass was preferred to porcelain and has worked effectively. The line received its first current of high voltage in a downpour of rain and no trouble was given by a single insulator, in fact no part of the equipment gave any trouble. The glass insulators are believed to be much superior to porcelain, and the lower cost is not the least thing to be considered. They do not require a test before being placed in service and the life without deterioration is longer.

Insulators are placed on special oak pins, 14 ins. long which have been boiled in paraffine oil. These pins are socketed in crossarms, 6 ft. and 8 ft. long, and are held firmly in place by plugs of ¼-in. round maple dowelling, driven through holes in the crossarm and pin. This method is used in preference to nails. The usual braces, bolted to crossarms and lag-bolted to pole, hold the crossarms in position. Fig. 2 shows the pole with crossarm and bracket construction and gives other measurements in detail. The poles are 40 ft. and 30 ft. long, with 7-in. tops and 13 ins. diameter, 6 ft. from the base. They were shipped from L'Anse, a northern Michigan timber point.

Considerable difficulty was experienced in securing poles that would pass inspection, and the writer's experience the last year with this part of overhead construction, indicates that Michigan will soon be barren of suitable timber for 30-ft., 35-ft. or 40-ft. poles. Already the telephone companies are using the Washington and Idaho cedar, and the increased freight charges make the poles from the latter states cost more than those that Michigan can furnish, though the latter are much superior in every way.

The poles are spaced 100 ft. apart, and are midway between tracks 15 ft. c. to c.; they are placed on an average of 7 ft. in the earth. All poles are tarred on the butts and painted from ground line to roof. Where poles were set in marsh or swampy ground they were well barrelled. At the side of each sixth pole is driven a 12-ft. section of galvanized iron pipe to which is connected a No. 6 copper wire, leading directly to the top of pole and tapped into a barb wire carried on a top-groove glass cable insulator. These pipes form a good earth connection for lightning discharges that may strike the high-tension circuits. The barb wire is of large size and composed of two No. 9 B. & S. wires; this was used in the belief that there would be less danger of breakage, than with a smaller size, which in falling would menace the high-tension wires. The top-groove insulator, on which the barb wire rests, is not used for insulation, but after some investigation, it was found that this form of support for barb wire was the cheapest and most substantial.

The first circuit runs continuously without transposition from the power house to Macatawa, while the second circuit receives one complete turn or twist between the power house and the Zeeland substation and between the latter and Macatawa. Direct-current feeders of aluminum are also used and these were supported on the trolley brackets, rather than upon an additional crossarm. This method is not only neat and substantial, but less expensive than additional crossarms. The trolley bracket is of 2-in. steel tubing, with heavy re-enforced castings. These brackets were fastened to the pole by lag screws and machine bolts, the latter being used where extra strength was required. The brackets are very strong and are specially adapted to interurban high-speed work. It will be noticed that this bracket is braced both from above and below the horizontal arm. Brackets are placed 20 ft. above the rails and 8 ft. 10 ins. from the lower crossarm. On the 40-ft. high-tension poles, a distance of 5 ft. 5 ins. is maintained below the telephone circuit and horizontal arm of brackets, with a separating distance of 20 ins. between the two No. 10 copper telephone wires. Steel thimble, angle, drive brackets are used for supporting the pony glass insulators.

FIG. 1. SINK HOLE ON THE GRAND RAPIDS, HOLLAND & LAKE MICHIGAN ELECTRIC RY.

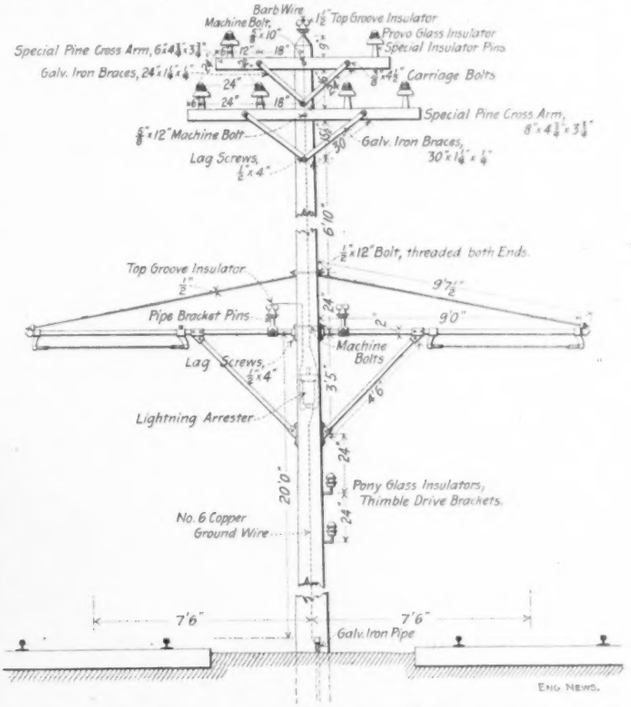


FIG. 2. POLE AND WIRE CONSTRUCTION OF THE GRAND RAPIDS, HOLLAND & LAKE MICHIGAN ELECTRIC RY.

The transpositions of the telephone wires occur every four poles and a straight drive bracket with a transportation glass insulator is used. The transpositions are made by soldering No. 12 weatherproof insulated copper wire across incoming wires. Thus far the telephone circuit has been very sensitive and worked well, but as soon as a ground occurs, the circuit is then too noisy to hear ordinary speech. Telephones are installed at the power house, turnouts, substations, offices and car barns. A dispatcher is employed to direct the movements of the cars by the medium of the telephone line.

The General Electric M. D. type of lightning arrester is installed and four of these are placed to the mile, giving the most efficient lightning protection for the direct-current circuits. The trolley wire used is No. 000 figure 8 section supported by cap and cone hangers made by the Ohio Brass Co., Mansfield, O., which also supplied the trolley brackets.

Taps from direct-current feeders to trolley wire are made on every twelfth pole and consist of a special mechanical aluminum clamp joint soldered to No. 0 insulated stranded copper cable. This is supported along the horizontal arm of trolley bracket by special insulator clamps, and then passes into feed-in ears attached to the hangers. The direct-current aluminum cables are connected by mechanical joints, the receptacles being compressed on the cable and joined by a lock nut, with right and left-hand threads. The usual strain guys are used where necessary, always broken by globe strain insulators. Through several villages that the road passes span construction is resorted to.

The passenger equipment consists of 10 closed cars, six 47 ft. and four 41 ft. long, weighing 23 and 25 tons, or 4 tons more when loaded. The shorter car can seat 46 passengers Each truck has two 50-HP. Lorain Steel Co.'s motors. The cars have the Magann storage air brake and Smith hot-water heater. Air compressors for charging the brake reservoirs are installed at the power house and the Macatawa substation. Five 50-ft. cars have been ordered. There are also some smaller open and closed cars, three 35-ft. closed freight cars resembling the passenger equipment, six 26-ft. box cars, six 30-ft. gondolas, a combination freight locomotive and snow plow, and a Ruggles rotary snow plow. A car shed and shop are located at the Macatawa substation, and another will be built this spring at Jenison.

The city of Grand Rapids has a population of 90,000 and the line will serve an outside population of about 30,750 in the villages and townships, with about 4,000 additional summer population.

Cars are operated on a headway of one hour and require at the present time 1½ hours for the trip from Grand Rapids to Holland, or three hours for the round trip. This time is to be reduced as the roadbed is bettered, and later, during the summer months, a maximum speed of 45 miles per hour will be realized, with an average speed of 26 miles per hour, including stops. The running time between Holland and Macatawa Park is about 30 minutes. The interurban cars run on Grandville Ave. in Grand Rapids to the downtown loop. While for some distance double track is used, single track with turnouts prevails. This spring a double-track road from the terminal of the electric line to the loop downtown is to be constructed.

Village franchises call for a rate not to exceed 1½ cts. per mile for passengers, with no fare accepted less than 5 cts., but the steam railway competitor has recently reduced its rates, and as a result the interurban company is making special rates during certain hours of the day, when the steam road has trains moving between terminal points. For track privileges in Grand Rapids, the interurban company receives 2 cts. on every fare in either direction on local or interchanged traffic, free transfers being given and the local Grand Rapids road provides train crew and power, furnishing and maintaining the track.

The rates for freight are low, ranging from 2½ cts. to 23 cts. per 100 lbs., dependent upon distance, rate basis, and classification. The express rates vary from 20 cts. for a package weighing not more than 10 lbs. to 45 cts. for packages weighing from 50 to 100 lbs. Over 100 lbs. a rate of 45 cts. per 100 lbs. is made. These rates, however, vary somewhat, dependent upon the distance, classification and risk. While on the Grand Rapids Railway Co.'s tracks freight cars operate on a mileage basis.

The railway was financed and built by the Detroit Construction Co., of Detroit, Mich., Mr. Ray being the electrical engineer for that company. The contract for the power plant complete was awarded to the Arnold Electric Power Station Co., of Chicago.

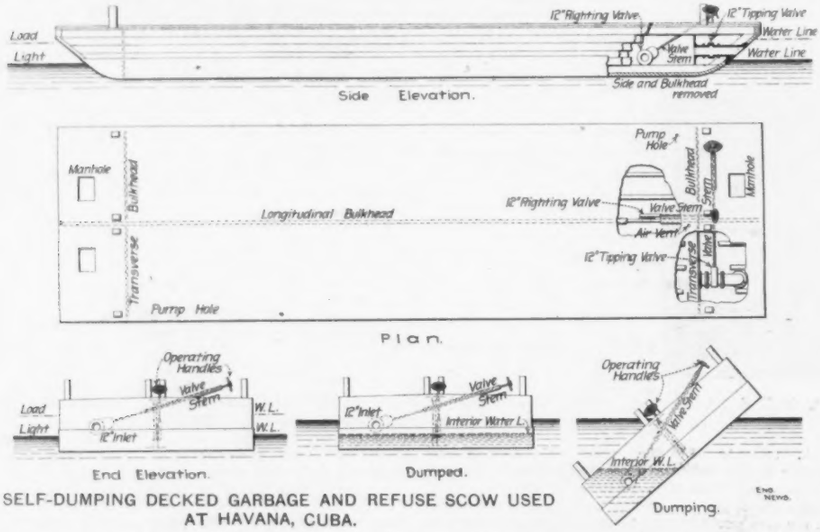
A SELF-DUMPING DECKED GARBAGE AND REFUSE SCOW, USED AT HAVANA, CUBA.

By T. Warren Allen.*

The accompanying illustration shows a self-dumping decked scow, designed by me and now in use by the Department of Street Cleaning and Parks of the city of Havana, Cuba, for taking garbage to sea.

The method of operation is shown by the drawing, which does not require much explanation. The scow is built with a central longitudinal watertight bulkhead, making two compartments. One valve, called the tipping valve, is used to let water into one compartment of the loaded scow. When this compartment is full or nearly so the scow is tilted down so that the load slides off. The tipping valve is then closed and the righting valve, which opens communication between the two compartments, is opened, and the water flows from the full compartment to the empty one until the scow is righted, when it is towed in and pumped out. Wood, taken from the garbage, is used to generate steam for the pump. The time from opening the tilting valve to time scow dumps is about six minutes; in four minutes more the scow is on an even keel again.

This method of dumping garbage at sea cannot be improved upon, as the cost of building the scow is but little more than for a plain decked scow, and the cost of operation could not be less.



A SELF-DUMPING DECKED GARBAGE AND REFUSE SCOW USED AT HAVANA, CUBA.

*Tacon, No. 3, Havana, Cuba.

THE FOREIGN COMMERCE OF GREAT BRITAIN, says the last Board of Trade Report, amounted last year to $4,352,923,590; or only $34,320,950 less than in 1900, the highest record reached. The exports have declined, however, $53,465,535, or 3.6%, while the re-exports show a gain of 7.3%.

COMMITTEE REPORTS AT THE ANNUAL MEETING OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

(Concluded from page 236.)

Rails.

Two of the most important subjects to be reported on are rail sections and specifications. It might have been better to have stated these subjects as rail sections and process of manufacture. In naming specifications as an important subject, we had in mind, however, a specification that would cover the process of manufacture other than any specification now in general use. The above subjects were selected not only on account of their importance, but also for the reason that it is desirable that the railways agree on a uniform practice in these matters.

RAIL SECTIONS.

The rail mills have furnished the percentages of their total output of rails rolled to Am. Soc. C. E. Sections during 1901 as follows:

National Steel Co.	55.6
Pennsylvania Steel Co.	90.2
Illinois Steel Co.	76.0
Cambria Steel Co.	75.0
Carnegie Steel Co.	70.0
Maryland Steel Co.	52.1
Lackawanna Steel Co.	37.2

The low percentage of Am. Soc. C. E. output from the Maryland Steel Co. is explained by the fact that a large amount of rail of special pattern was rolled for export; also that the Pennsylvania Lines East of Pittsburg and the Baltimore & Ohio R. R. used special sections. The Lackawanna Steel Co. rolled a large tonnage of the Dudley section for the New York Central Lines.

We referred in 1901 to some difficulties which were encountered at the mills, due to finishing the rails at a lower temperature, and suggested that it might be necessary to modify the heavier sections in common use, especially the Am. Soc. C. E. sections, which have come into wide use. The difficulties still exist, and in our opinion sooner or later some changes will have to be made, either in sections, or in the mill practice in rolling.

It was suggested at our last meeting that the sections should not be changed without taking up the matter with the American Society of Civil Engineers, and since that time that society has decided on the appointment of a committee on rail sections, which should summarize the present state of the art of rail-making and cover an investigation of all questions relating thereto, whether of sections, composition of the material or process of manufacture. The personnel of this committee has not been announced. It is hoped that it will be made up of men directly connected with the use of rails; also, that a long time will not be necessary to reach conclusions and formulate a report. We should co-operate in every possible way and freely furnish any information we can in the matter.

We are fully aware of the number of committees that have been appointed from time to time to report on the chemical composition of steel, the methods of rolling to make a first-class steel rail, and that there has been a great deal of time and work expended on this matter by these committees. Some of the reports have gone into the subject very fully, and at the conclusion have recommended that the metal should receive more work at the proper low temperature. This recommendation has not been adopted by railway companies because the mills have asked a higher price per ton for the rail; instead, they have continued to buy rails of poor quality, and often without any tests or inspections whatever being made.

We think we fully appreciate that in asking the manufacturers to improve their methods of rolling and give more care and attention to the manufacture of rails that the railway companies should be willing to share in any necessary additional expense: There is no use in trying to make a good rail by the chemical composition alone. The evidence clearly points to the fact that much better rails can be made from the steel now in use, provided it receives the proper treatment in rolling. We desire, therefore, to put ourselves clearly on record on this point, as it is a vital one and underlies the whole matter.

SPECIFICATIONS.

We strongly advocate the use by railways of a uniform specification and uniform methods of testing. In our last report we submitted for the information of the Association the proposed standard specifications recommended by Committee No. 1 of the American Section of the International Association for Testing Materials, which have since been adopted by the American Section, at their annual meeting in June, 1901. We now offer these specifications, with some amendments, for discussion and use by the members of this Association.* These specifications are not entirely satisfactory to us, but in order to take a step toward uniformity, we advise their use instead of waiting for a perfect specification. Any additions or modifications needed which may develop from an actual test may be made as necessary.

*Eng. News, July 4, 1901. The amendments referred to consist in inserting after paragraph No. 3 the Pennsylvania R. R. shrinkage clause (given further on in the report), and in changing the standard length from 30 to 33 ft., with 27 ft. for short lengths.

PROCESS OF MANUFACTURE.—Details of processes of manufacture have generally been neglected, except in the one aim of the mill to turn out the largest tonnage in the shortest time at a minimum cost. This has enabled the railway companies to buy rails at a lower price, even if they do not wear as well as desired, but if we are sincere in our demands for better rail, we must in the future pay more attention to these details.

It is conceded that the quality of rolled steel depends on its chemical composition and the heat treatment it receives in connection with the work of rolling, and in order to get the best results, steel of good uniform chemical composition should be used and rolled at a uniform low temperature, the ingot or bloom used being large enough to allow the work in rolling to break up the coarse grain, as it is not the total amount of reduction in rolling that produces the best results, but a sufficient amount of work must be done at the proper low temperature—the work at the higher temperatures merely changing the form of the mass without changing its structure.

The bad effects of too high finishing temperature are fully recognized by the rail manufacturers, some of whom are now rolling their heavier rails at a much lower temperature than formerly. We appreciate their efforts, and, as showing that the engineers were willing to meet the manufacturers half way, a change in the section of the heavier rails was suggested last year by increasing the thickness of metal in the flanges in order to carry the heat longer and allow the work of rolling on the head at the proper low temperature, provided the manufacturers found it necessary to make this change in order to produce the best results.

We take great pleasure in calling attention to the following papers that have appeared during the past year, as treating on the points referred to:

"The Correct Treatment of Steel," by C. H. Ridsdale, Iron and Steel Institute, Vol. 2, 1901; also abstract of same in Engineering News, Oct. 3 and Oct. 10, 1901.

"Some Suggestions as to Specifications for Steel Rails," by E. F. Kenney, Engineer of Tests, Pennsylvania R. R., in Engineering News, Oct. 3, 1901.

"Rail Rolling at Lower Temperatures During 1901," by S. S. Martin, Superintendent Maryland Steel Co., in "Iron Age," and reprinted in "Railroad Gazette," Jan. 3, 1902.

"Rolling Rails at Low Temperatures," "Railroad Gazette," Jan. 24, 1902.

There is no use advocating any change of section or method of rolling unless we can have some reliable check that the rails are being rolled at the proper low temperature. At our last meeting it was suggested that the amount of shrinkage in the rail, after it has been cut at the hot saw, is the best and easiest method of checking the finishing temperature. We note that the Pennsylvania R. R., in its new rail specifications (Oct. 1, 1901), has embodied this shrinkage clause for a 30-ft. rail, which we give below, modifying it for a 33-ft. rail, which is our standard:

The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws of 6 ins. for 85-lb. and 6¼ ins. for 100-lb. rails, and no artificial means of cooling the rails shall be used between the finishing pass and hot saws.

CHEMICAL PROPERTIES.—The new rail specifications of the Pennsylvania R. R. is as follows:

The steel of which the rails are rolled shall contain not less than 0.40, nor more than 0.55% of carbon where the phosphorus exceeds 0.07%. Where the phosphorus is .07% or less, the carbon shall not be less than 0.45, nor more than 0.60%. The manganese in no case shall exceed 1.20%, and where the phosphorus exceeds 0.07%, the manganese shall not be higher than 1%. Also in no case shall the phosphorus exceed 0.10%.

It will be noticed that the carbon and manganese are decreased when the phosphorus is above 0.07%, in order to give steel of an equivalent hardness, and at the same time to guard against the steel being too hard and brittle. We are advised that the Pennsylvania R. R. now advocates higher carbons, as the drop tests show that rails finished at a lower temperature give a greater deflection than formerly, when finished at the higher temperature. It also finds that higher carbons can be used with safety when the proper check is kept on the low-finishing temperature. It specifies deflection of not more than 2¾ ins. for 100-lb. rails after the first blow.

We suggest that our members direct their rail inspectors to keep a record of the amount of shrinkage, with the results of drop tests and chemical composition of each lot of rails they receive. This information, with the results of the rails in service, will be valuable in making a final specification.

TEST PIECES AND METHODS OF TESTING.—The specifying of a drop test seems to be almost universally regarded as essential, and yet, unless the portion of the ingot from which the test piece comes is known, the drop test may be quite misleading. The test piece should be taken from some designated location, preferably from what was the top of the ingot, for then we are reasonably sure that all the rails represented by that test piece are at least equal to, and probably better, than the test piece.

TEST IN SERVICE.—It is recommended that the following simple test be made by those interested in the wear of rails of different compositions and manufacture: Take a curve where rails are known to wear rapidly, and lay the different kinds of rail alternately. The rails are then acting under precisely uniform conditions, and it will take but a few months to determine what rail is giving the best results. If this experiment be made anew each year for a few years, the road making such a test would have valuable information, which will be useful in helping to decide on the kind of rail which will give the best results in actual service.

R. Trimble, Pa. Lines; J. T. Richards, Pa. R. R.; Thomas Purcell, Mex. Nat. Ry.; A. W. Johnston, N. Y., C. & St. L.; C. E. Wickham, C., R. I. & P.; R. W. Hunt, Chicago; G. B. Woodworth, C., M. & St. P.; F. E. Abbott, Chicago; Wm. R. Webster, Philadelphia; W. T. Manning, B. & O.; H. Pierce, C. & O.

Track.

MAINTENANCE OF LINE.

Tangents shall be adjusted by throwing the tangent between summits, or by throwing curves to meet tangent, or by partially throwing curves and partially throwing tangents, as may produce the least work. Centers shall be set with transit to insure accurate line.

Easement curves shall be used as follows: For roads not exceeding speed of 30 miles per hour, on all curves exceeding 2°; roads not exceeding 60 miles per hour, all curves exceeding 1°; roads where higher speed is attained, all curves exceeding 30 mins.

Easement curves shall be used between curves of different degrees in the same way that they are used between curves and tangents. The length of easement curves shall be the same as the distance in which the curve elevation is run out; therefore, as the superelevation of curves depends not alone on the degree, but also on the speed of trains, the length of the easement curve should vary in the same manner. For ordinary practice, a chord length equivalent to 100 ft. for each degree of variation in curvature is recommended. Where the distance between curves will not allow this, or for other reasons, a chord length of 25 to 30 ft. may be used. For very high-speed roads, a chord length equivalent to 150 ft. or more is recommended.

Any form of transition curve is satisfactory which gradually changes the degree of curvature, and in which the length of chord per degree of variation can readily be changed to suit each particular case, the essential point being that the length of the easement curve shall be the same as the distance in which the superelevation of curve is raised from zero to full elevation. We recommend any transition curve of the Searles, Crandall, Holbrook, or cubic parabola type, which shall be susceptible of being run in by deflection or offset.

Permanent witnesses shall be placed at points of tangent, points of spiral, points of change of curvature, summits, and at such other points along curves or tangents as will enable the alinement to be identically reproduced with a transit.

MAINTENANCE OF SURFACE.—For elevation on curves the inner rail shall be maintained at grade. The following approximate formula will give essentially correct theoretical elevations for the outer rail of curves, and is recommended for ordinary practice, but must be modified to suit special conditions:

$$E = \frac{G\ V^2}{32.16\ R}$$

E = elev. in feet, V = vel. in ft. per. sec.,
G = gage, 4,708 ft., R = radius in feet.

This formula will give results which are expressed in the accompanying table, and are recommended for use, with the modifications given below:

Deg.	Velocity in Miles per Hour. 10	15	20	25	30	35	40	45	50	55	60	65
1	2/16	1/4	1/4	3/8	5/8	12/16	1	1⅜	1⅝	2	2¾	2¾
2	1/8	5/16	1/2	7/8	1 3/16	1⅝	2½	2⅞	3½	4	4¾	5½
3	1/4	1/4	3/4	1¼	1¾	2⅜	3½	4	4⅞	6	7⅛	8⅜
4	1/4	3/8	1 1/16	1⅝	2⅜	3¼	4¼	5⅜	6⅝	8	..	..
5	3/8	3/4	1 5/16	2 1/16	3	4	5¼	6⅝	8¼	..	..	..
6	7/16	13/16	1⅝	2½	3 9/16	4⅞	6 3/16	8	..	..	..	..
7	½	1 1/16	1⅞	2⅞	4⅛	5⅝	7⅜	..	..	..	..	..
8	9/16	1¼	2⅛	3 3/16	4¾	6½	8⅛	..	..	..	..	..
9	⅝	1⅜	2⅜	3¾	5⅜	7¼	..	..	..	..	..	..
10	11/16	1½	2⅝	4⅛	5 5/16	8 1/16	..	..	..	..	..	..
11	¾	1 11/16	2⅞	4½	6½	8⅞	..	..	..	..	..	..
12	⅞	1⅝	3⅛	5	7⅛	..	..	..	..	..	..	..
13	⅞	2	3 7/16	5⅜	7¾	..	..	..	..	..	..	..
14	1	2 1/16	3 11/16	6⅛	8⅝	..	..	..	..	..	..	..
15	1 1/16	2 1/16	3 15/16	6¼	8⅞	..	..	..	..	..	..	..
16	1⅛	2 1/16	4¼	6⅞	..	..	..	..	..	..	..	..
17	1¼	2⅜	4½	7	..	..	..	..	..	..	..	..
18	1¼	2⅝	4⅝	7½	..	..	..	..	..	..	..	..
19	1⅜	2⅞	5	7⅞	..	..	..	..	..	..	..	..
20	1⅜	3 1/16	5¼	8¼	..	..	..	..	..	..	..	..

Since the elevation required is a function of, and depends upon, the train speed, this speed is the first element to be determined. In general, as a matter of safety, the preference should be given to fast passenger traffic. The slower freight traffic must also be considered, and it often happens that on freight lines the correct elevation for passenger service would be so excessive for freight service that the train resistance would be increased enough to materially reduce the tonnage hauled. In this case, a compromise must be made between the two rates of speed, and the curve elevation used will be too small for passenger service (theoretically), but practicable for freight service.

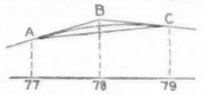
When the theoretical elevation is reduced the speed of passenger trains should be correspondingly reduced. This is a problem which must be decided on each road, according to the relative importance of its freight and passenger traffic. It must not be understood that it is unsafe to run over a curve at a higher rate of speed than that for which it is elevated. A train may safely run 10 miles per hour over a curve which has no elevation. In the same manner a train may safely run 60 miles an hour over a curve elevated for a speed of but 50 miles an hour. Such an extreme should be avoided. It results in increased flange and rail wear and cost of maintenance. The curve can never ride perfectly and the danger of accident is increased.

The maximum allowable elevation of curves depends entirely on local conditions. On fast passenger roads, where crushed stone or other stiff ballast is used, a difference in elevation of 8 ins. is successfully maintained, but for ordinary practice a maximum elevation of 7 ins. should be used, and when greater elevation is required, speed shall be reduced until the 7 ins. elevation gives satisfactory results.

The superelevation of curves shall be zero at the point of spiral and shall increase to full elevation at the end of the spiral or point of simple curve. In ordinary practice, it is recommended that the elevation be run out at the rate of 1 in. in 60 ft., but this will be modified by the same conditions that should vary the length of the easement curve used.

VERTICAL CURVES.—Vertical curves shall be used wherever changes occur in the rate of grade. Theoretically, the changes in the rate of grade for each station of the vertical curve should be equal. A section of a parabola as applied to this purpose so nearly approximates this condition that the following formula is recommended for practical use:

Let AB, BC be two grades in profile, intersecting at station B, and let A and C be the adjacent stations. It is required to join the grades by a vertical curve extending from A to C. Suppose a chord drawn from A to C. The elevation of the middle point of the chord will be mean of the elevations of grade at A and C. One-half of the difference between this and the elevation of grade at B will be the middle ordinate of the curve. Hence we have:



$$M = \tfrac{1}{2}\left(\frac{\text{grade A} + \text{grade C}}{2} - \text{grade B}\right)$$

in which M = the correction in grade for the point B. The correction for any other point is proportional to the square of its distance from A or C. Thus the correction at A + 25 is 1-16 M; at A + 50, it is ¼ M; at A + 75 it is 9-16 M; and the same for corresponding points on the other side of B. The corrections in the case shown are subtractive, since M is negative. They are additive when M is positive, and the curve concave upward.

The following is another method which is recommended as of equal accuracy, the use of which may be optional: The vertical curve shall consist of as many chords as there are whole tenths of a foot in the algebraic difference between the two gradient lines, less one. The length of the chord shall generally be 100 ft. The change from one gradient line to another shall be made by variation in rate of grade for each chord equal to the algebraic difference between the rates of the two gradient lines, divided by the whole number of tenths in the algebraic difference. This change of rate is approximately 0.1 ft. per chord.

To change from grade of plus 0.6 per 100 to a grade of minus 0.5%: Number of chords in curve are 11 minus 1, equal 10. Length of curve 10 × 100, equal 1,000 ft.

Rate of change from chord to chord equals $\frac{1.1}{11}$ equals 0.1

If it is necessary for any reason to change the length of the curve, the change is made in the length of the chord, the rate of change remaining the same.

Rate of grade on	1st chord	equals plus		0.5
" " " "	2d	"	"	0.4
" " " "	3d	"	"	0.3
" " " "	4th	"	"	0.2
" " " "	5th	"	"	0.1
" " " "	6th	"	"	0.0
" " " "	7th	"	minus	0.1
" " " "	8th	"	"	0.2
" " " "	9th	"	"	0.3
" " " "	10th	"	"	0.4

The proper length of vertical curves depends on the difference in rate of grade of the intersecting tangents. As a rule, such curves should not be less than 200 ft. or more than 800 ft. long.

(Note.—The remainder of this report deals mainly with methods of tamping ballast, trackwalking and tool equipment for section gangs.—Ed.)

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Masonry.

Standard specifications and other data in regard to practice and customs as to masonry construction have been obtained from nearly 70 railways of the United States, Canada and Mexico. Of this number 50 roads may be classed as of some considerable extent and experience. A review of the best specifications seems to show a rather surprising substantial agreement in numerous main

points. As to stone masonry, for instance, some roads name coping and bridge-seat masonry and then classes 1, 2 and 3 for what may be termed the body of the work; others name classes 1, 2, 3 and 4; and still others, while not stating classes by numbers, yet, under some nomenclature, have virtually these three or four classes. It seems feasible to have substantial agreement on some classification that can be made to apply to general practice throughout the country. In doing this it is not anticipated that the committee will be able to present a complete specification that will meet with approval of all parties. It is conceivable, however, that an outline may be made that will differ but little from the best practice, and that can, by minor amendments, be easily made to include the particular specialities that any road may think desirable for its conditions.

One feature has been forcibly brought to the attention of the committee by responses from several first-class roads. This is perhaps best indicated by a quotation from one communication from an important first-class railroad: "All our masonry is built by our own men, and we have no printed specifications, as the foremen understand how the work should be done." Almost the same language is used in responses from chief engineers of several other roads. It is not this committee's province or desire to take issue with this, in many respects most excellent practice; but even with such practice it might be found worth while to have a general printed description of what is considered requisite for good work. The outline that the committee ventures to present might perhaps be better termed a "description" of several classes of masonry, rather than a formal "specification." It would be something that, with a few additional requirements printed on accompanying sheets to show what other special conditions, if any, are to be exacted from a contractor, would then constitute a complete specification, and could be made part of a contract. One point of objection that is found in several good specifications for masonry is that, along with the outline and kind and quality of work that is wanted, various provisions not in themselves descriptive of the masonry are included, such as a clause that "the presence of the engineer or inspector shall not release in any degree the responsibility of the contractor;" or, "that no conventional measurement will be allowed, any rule or custom of the country to the contrary notwithstanding." Such provisions, while entirely right and proper, in many cases are not, it would seem, any part of a "description" of masonry, which is, perhaps, after all, pretty nearly what "specifications for masonry" should be. The necessary proper restrictions as to contract work can easily be given on a separate sheet and with increased force and clearness, from the very fact that they are separately stated.

Before giving a suggestion for description of the several classes of stone masonry a general definition of masonry is submitted, as follows:

Masonry, in its widest sense, includes all constructions of stone or kindred substitute materials in which the separate pieces are either carefully placed together, with or without cementing material to join them, or, if the pieces are not separately placed with care, are encased in a matrix of firmly cementing material.

After offering for criticism a definition for masonry, the committee further presents a suggestion for some particular descriptions hereinbefore referred to, in the hope that it may do something to harmonize good railroad practice in usual masonry construction. The best "description" or "specification" will not insure good work, if construed or carried out by incompetent, careless or dishonest agents, but is yet of much value, even with unsatisfactory agents; and under usual conditions will go far towards securing good, strong work at reasonable cost. The attempt is made to furnish enough of an outline to constitute a good, common nucleus, to which different parties may add other particulars descriptive of the peculiarities of their various situations. The outline here given might be printed on two leaves of usual contract form, leaving sufficient blank space at end of each class description for such special amendment as might be desired.

DESCRIPTION OF STONE MASONRY.

All stones used for masonry shall be sound, durable, not liable to be affected by the weather, from sources approved by the engineer, and shall be laid on their natural beds.

MORTAR for laying up stone masonry, unless otherwise expressly stated, shall consist as follows: Either 1 part of approved Portland cement to 4 parts of good, sharp sand, or 1 part of approved natural cement to 2 parts good, sharp sand, all to be very carefully measured and mixed, and to be used within one hour after mixing, and always before it shall have commenced to set.

MORTAR for pointing shall consist of 1 part Portland cement to 1 or 2 parts of sand.

FINISHED COPINGS, PARAPETS, BRIDGE-SEATS AND OTHER FINELY DRESSED SPECIAL STONES.—Work that comes under this head shall be of selected stone, of the best quality, free from defects, shall be very accurately cut, being finely bush-hammered where called for, and as per plan and dimensions given. To be laid to ⅜-in. joints.

FIRST-CLASS MASONRY.—First-class masonry will be laid in Portland cement mortar, in regular courses, each stone being carefully cleaned and dampened, if desirable, before setting. The face stones shall be rock-faced, with edges pitched to a straight line, and no projections exceeding 3 ins. A draft line, 2 ins. wide, shall be cut at each angle in the masonry. The beds throughout and the joints for 12 ins. back from the face shall be dressed to lay to ½-in. joints. No course shall be less than 12 nor more than 30 ins. in thickness, and the thickness of any course shall not exceed the course below it. Stretchers shall not be less than 3 ft. long, and not less than 18 ins. wide, nor less in average width than 1¼ times its height, and at no single place less in width than height.

HEADERS must not be less than 4 ft. long, where the wall is of sufficient thickness, and the majority shall exceed that length. Where the wall is not over 5 ft. thick, they shall extend entirely through the wall. Headers will extend at least 20 ins. beyond the width of the adjacent stretchers. The usual arrangement shall consist of headers and stretchers, alternately arranged, so as to thoroughly bond together the face stones and the backing; for rare exceptions, two stretchers will be allowed to one header, by special permission, to cover each such case. The stones of each course of the face must break joints at least 1 ft. with those of the course below. No hammering will be allowed on any stone after it is set. Each stone must be set upon a full bed of fresh mortar, the broadest bed down, and brought to a firm and level bearing without spalls or pinners.

BACKING.—The backing shall consist of large-sized, well-shaped stones laid in full mortar beds and breaking joints so as to thoroughly bond the work together. The spaces between the larger stones shall not be over 6 ins. in width and shall be thoroughly filled with small stones and spalls laid flat, and all spaces flushed full with mortar. The courses shall correspond with the face stone, but may be made up in part by two thicknesses, providing no stone less than 8 ins. thick be used. In cases approved by the engineer, satisfactory Portland cement concrete may be used for backing.

SECOND-CLASS MASONRY.—Second-class masonry shall be laid in cement mortar. The face stones shall be rock-faced, no projections over 3 ins., edges pitched to a straight line, shall have parallel beds and rectangular joints. The beds and joints for 8 ins. back from face shall be dressed to lay not over ¾-in. joint. The stones need not be laid up in regular course, but shall be laid level on their natural beds, shall be well bonded, having at least one header 3 ft. 6 ins. long to every three stretchers with joints well broken; no stone shall be less than 8 ins. thick, and no stone shall measure in its least horizontal dimensions less than 12 ins., nor less than its thickness.

BACKING.—The backing shall consist of well-shaped stones, not less than 6 ins. thick, and of which at least half shall measure 3 cu. ft., to be laid in full mortar beds, with joints well broken, well bonded together, and with the face stone. All spaces to be thoroughly filled with small stones and cement mortar.

THIRD-CLASS MASONRY.—Third-class masonry shall be laid dry or in mortar, according to the direction of the engineer. It shall consist of good quarry stone, laid upon the natural beds, and roughly squared, on joints, beds and faces, the stones breaking joints at least 6 ins.; the wall shall be bound together by headers, occupying one-fifth of the area of the face of the wall front and rear, and extending through walls 3 ft. or less in thickness; no stone shall be used in the face of the wall less than 6 ins. thick or less than 12 ins. on the least horizontal dimensions.

OUTLINE SPECIFICATION FOR CEMENT CONCRETE.

CEMENT.—Natural hydraulic cements used shall be freshly made, of uniform quality, so ground that 75% will pass through a sieve with 10,000 meshes per sq. in., shall have a tensile strength on 1 sq. in. section of not less than 100 lbs. at age of seven days (one day in air and six days in water), and not less than 160 lbs. per sq. in. at age of 28 days. When mixed with equal parts of good, sharp sand, shall have a strength of not less than 80 lbs. per sq. in. at age of seven days (one day in air and six days in water), and not less than 140 lbs. per sq. in. at age of 28 days.

Portland cements used shall be of uniform quality, so ground that 90% shall pass through a sieve with 10,000 meshes per sq. in., shall have a neat tensile strength on 1 sq. in. section of not less than 350 lbs. at age of seven days (one day in air and six days in water), and not less than 500 lbs. per sq. in. at age of 28 days. When mixed with three parts of good, sharp sand, shall have a strength of not less than 160 lbs. per sq. in. at age of seven days (one day in air and six days in water).

Cement shall be subject to such additional test requirements as may be especially called for.

PROPORTIONS.—Cement and Sand: For natural hydraulic cements, the proportion of cement to sand shall not be greater than 1 to 1, nor less than 1 of cement to 2 of sand.

For Portland cements, the proportion of cement to sand shall not be greater than 1 of cement to 2 of sand, nor less than 1 of cement to 5 of sand.

BROKEN STONE to pass through 2-in. ring, screened gravel or substitute materials; no more of this material shall be used than can be effectually covered and united together by the cementing mortar. It shall generally be moistened before being combined with the other ingredients.

WATER.—Sufficient water shall generally be used to make a moderately wet concrete.

The above statements as to proportions are intended for work in the open air and during moderate weather, and such proportions may be varied for conditions of use under water or in freezing weather, the modifications in such cases consisting mainly of using a larger proportion of cement and a less proportion of water than would be used under conditions first stated.

MIXING.—A standard for mixing of the various materials is as follows: Mixing Cement Concrete by Hand Labor.—The proper amount of sand shall be spread out evenly on a smooth, tight platform; then add the proper amount of cement and thoroughly mix the two until the mass is of an even color; this amount of mixing should be equal to four times turning over with a shovel; then add a proper amount of water for the conditions of the work in hand and mix thoroughly again until a good plastic mortar is formed; then add the proper amount of broken stone or clean gravel stones, and again thoroughly mix the mass until the stones are covered with the mortar and all voids completely filled; the amount of mixing for this part of the work should be equal to four times turning over with a shovel.

Cement concrete may also be mixed by well-made mixing machines. Machines will be preferred which permit, first, the dry mixing of the cement and sand, then the addition of the water and stone; also such machines or arrangements as conveniently permit the indefinite continuance or repetition of the mixing process will be preferred to those that have a fixed limit for the amount [illegible] they can conveniently give to a given charge [illegible] of concrete.

Whether in mixing by hand labor or by machine [illegible] care should be taken to keep the mixture entirely [illegible] from all foreign substances, like paper, chips, sticks, etc.

A concise statement of the intent of the above [illegible] tions for cement concrete may be made something as follows: Using cements that are in quality not any [illegible] but rather above, the average of the good brands [illegible] market, reliable cement concretes may be used with confidence under appropriate conditions, composed as [illegible] For natural hydraulic cement concrete a good mixture [illegible] 1 part cement, 1 part sand and 2 parts broken stone [illegible] be considered as good, strong concrete, as practicable [illegible] be made with natural cement; 1 to 2 to 4 or 4½ [illegible] considered as poor and weak concrete as practicable [illegible] should be made with natural cement, to be used in [illegible] work to be classed as durable and sufficient for [illegible] usually placed upon masonry of ordinary dimensions.

For Portland cement concrete a good mixture of 1 [illegible] 2 to 4 may be considered as good, strong concrete as [illegible] tically need to be used for any piece of Portland cement [illegible] concrete of appreciable bulk. A good mixture of 1 to 2½ [illegible] 6 may be considered as giving a concrete of sufficient [illegible] strength, when of proper dimensions, for any ordinary [illegible] masonry construction, and, at many times and places [illegible] ample for very heavy work.

A good mixture of 1 to 4 to 8 stone may be considered as [illegible] giving a concrete of sufficient strength, when of proper [illegible] dimensions, for much ordinary plain work in favorable [illegible] positions. With any of these Portland cement concretes [illegible] there may be judiciously used, on their exposed faces, a [illegible] "skin" or facing of rich Portland cement mortar, about [illegible] 1½ ins. thick, to be built up at the same time as the concrete backing, and both tamped well together. This facing should not be too rich in cement, not richer than 1 cement to 2 sand.

In some instances Portland cement concrete has been used in railway structures made by mixing the cement direct with certain gravels, as found in favorable banks, without screening to separate the sand and pebbles. It is not thought that such practice could be indorsed for frequent use, or as safe to follow, except with unusually favorable materials, and by individuals whose extensive personal experience might warrant them in it.

There is some difference of opinion among engineers as to the advantages, respectively, of broken stone or natural rounded pebbles for use in concrete. Both are used, and much good work is done with both of them. For the very best work good crushed trap rock or hard limestone will probably give somewhat stronger work with same quantities of cement than the natural rounded pebbles, especially for tests under one year in age.

COST OF CONCRETE.

It is very difficult to give any general statement that will be of value as to cost of concrete masonry work. Referring to railroad structures of Portland cement concrete such as abutments, culverts, arches up to 30-ft. span, of varying proportions in the concrete mixture, and in widely different situations, the cost per cubic yard for good work that has stood up to its requirements has been variously reported at from somewhat less than $5 up to about $10. In most of these situations the stone masonry that would have been considered right for the same place would have cost from 20% to 80% more.

If the structures are considered of equal value, the smaller saving may be well worth making, and the larger saving might many times help to determine the question as to whether a timber structure in bad order should again be renewed with timber or be replaced with something more permanent, upheld by concrete masonry.

An accurate account of cost is given herewith as a sample of good work recently done near Pittsburg, Pa., which is of interest. It is the report of construction of an arch built under traffic, April to June, 1901, near Pittsburg, Pa.

Semicircular arch, span, 26 ft.
Length of barrel, 62 ft.
Length of east wings, 22 ft.
Length of west wings, 21 ft.
Length of retaining wall returns at end of west wings, 30 ft.
Wing copings, 18 ins. thick and sloped.
Other copings, 18 ins. thick and horizontal.
Top parapet copings above intrados of arch, 5 ft. 6 ins.
Average height of bench walls, 10 ft.
Thickness of bench walls at spring line, 7 ft.
Thickness of arch at crown, 26 ins.
Height of haunch above spring line, 7 ft.

Up to present time (Feb 6, 1902) the general condition of the structure is perfectly satisfactory, there being no signs of weakness or indication of bad weathering. In massive masonry, the engineer in charge thinks general dimensions may be somewhat reduced, as compared with those used in ordinary first or second-class stone masonry for railroad purposes where it is proposed to build of Portland cement concrete.

In the concrete, Atlas American Portland cement was used throughout, with river gravel and sand. Two proportions were used, the weaker in foundations and backings, and the other in all face work and in the 26-in. ring work. One part cement, 2 parts sand, 10 parts gravel formed the weaker mixture. In the other we added one-half part cement. We secured our gravel in two sizes or grades, and the intention was to use 8 parts of the coarser and 2 parts of the finer. The finer grade contained no pebbles exceeding 1 in. in diameter, and was

screened by passing the gravel from the dredging machine over a screen. However, while this operation excluded all pebbles exceeding the size mentioned, it allowed a considerable amount of sand and fine gravel to go along with the coarse gravel in the so-called coarse grade. This necessitated a corresponding variation in our concrete mixtures as to the proportions of the two grades of gravel.

The proportion (2 to 8) was determined by treating both grades for voids. In building up the work, which was carried on in horizontal layers of 8 ins., a little mortar (1 to 2) was first placed against the face of the form, then the richer concrete mixture to a width of 12 ins., and the other mixture back of that. Then all was thoroughly (not heavily) tamped together. In forming the ring the entire 26 ins. was made of the richer mixture and the courses inclined approximately to the line of the radius, until an inclination of 45 to 50° was reached. This last inclination was then carried uniformly about to the top and finished somewhat as with a key built up in horizontal layers. The haunching was carried up with the ring, being formed with the weaker mixture. Horizontal and slope copings were made also of the richer mixture.

For lagging and all face work, single surfaced and sized hemlock boards, 6 ins. wide, were used, generally two boards thick. The face boards next to the concrete were put in place only just ahead of the concrete, in order to diminish as much as possible the effect of cracks and joints on the face of the finished concrete, due to shrinkage of the lumber.

An expansion or temperature joint was put in each wing, 4 ft. from the face of the arch. In another case the engineer would avoid this, if possible, and locate these joints within the limits of the arch itself, making them somewhat less conspicuous.

After the forms were all removed, the exposed surfaces were covered with a very thin grout, applied with a brush, like whitewash. This filled all the minute openings, and still did not produce a surface that would scale off. It was found that a rich grout did not do so well as one made of 1 cement and 2 sand.

The finished structure contained 1,493 cu. yds. of concrete masonry, total cost of which was $7,243.24. The cost per cubic yard concrete for material and labor was as follows:

MATERIAL.

Coarse gravel, at 19 cts. per ton, 1.03 tons.	$0.19½	
Fine gravel, at 21 cts. per ton, 0.40 ton....	.08½	
Sand, at 36 cts. per ton, 0.32 ton.....	.11½	
Cement, at $1.00 per bbl.....	1.53½	
Lumber	.43	
Tools and other storehouse accounts.....	.07¾	
		$2.43¾

LABOR.

Preparing site and cleaning up after completion of structure, at 15.5 cts. per hour.	$0.21	
Forms, at 23 cts. per hour.....	.28	
Platforms and buildings, at 23 cts. per hour.	.05	
Changing trestle, including service of work train and steam derrick car.....	.08½	
Excation, foundations, at 15.5 cts. per hour.	.31	
Handling material, at 15.5 cts. per hour...	.03¾	
Mixing and laying on concrete, at 15.5 cts. per hour.....	1.44	
		2.41¼
Total cost per cu. yd. of concrete.....		$4.85

Wages paid were as follows: Foreman mason in general charge, 40 cts. per hour; laborers, 15 cts. per hour; foreman, 25 cts. per hour; carpenters, 22.5 to 25 cts.

Referring to the above cost, perhaps it should be said that the general conditions were probably as favorable as any likely to be found. The gravel and sand was delivered from hopper cars into bins under each end of the trestle on ground high enough so that practically no material of any kind had to be lifted during its progress from the cars to its final position in the work. The mixing was done by hand on platforms about 16 × 24 ft., and mixtures averaging ¾ cu. yd. were usually made.

The work was begun April 1, 1901. Centers were erected May 1 and 2. The arch was closed May 16 and centers struck May 30, but not removed until about June 18. Filling over the completed arch was begun June 10 and completed on June 22. Trestle stringers were removed and track adjusted on new embankment July 8. No settlement whatever could be detected in the arch either before or after the removal of the centers.

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Improvement of Railway Grades and Alinement.

Radical improvements in existing grades and alinement are generally only considered and undertaken when the traffic—present or immediately prospective—is of such volume as to make it imperative that the tonnage handled per train be largely increased, if such traffic is to be carried in the most profitable manner to the railway company.

It is evident that on a line where there are few trains, a moderate increase in the length and curvature of a line or an increase in its grades can probably increase operating expenses by only a small amount, so that a moderate saving in cost of construction will justify such a change. On the contrary, where the number of trains is large, the increased cost of operating a train or a ton on the inferior line will be multiplied many times, and the increase in operating expenses will be large, and a large saving in cost of construction will be necessary to justify the adoption of the longer and more crooked line, or the line with heavy grades.

An increase in distance, curvature or rise and fall adds somewhat to the cost of running each train, but has no effect on the number of trains for a given traffic. An increase, however, in the rate of the limiting grade or limiting curve increases the resistance to be overcome, making necessary a shorter train behind any given engine, and therefore a greater number of trains for a given traffic, and generally each of these must be hauled over an entire operating division.

It is obvious, therefore, that the differences in grade necessary to be considered are much more powerful in their effect upon the cost of operating than are changes in distance, while curvature and rise and fall are generally far less important, in view of the amounts in which they are involved. Curves, if used so as to have a limiting effect, are of primary importance also, but the better practice does not so use them at present.

LIMITING GRADE.

Considering the question of grade with reference to economy, the steepest actual grade to be operated by a single engine may be called the maximum grade. It is not, however, always the grade which limits the weight or length of train, for several reasons: (1) The limiting grade is a virtual grade, and this may be different from the actual grade, due to a difference in velocity between the bottom and the top of the grade; (2) the steepest actual grade may be worked by a helper engine, and so fail to be the limiting grade on the basis of equivalent helper grades; (3) variations in the load over different parts of the division may cause some grade other than the steepest to become the real limiting grade, on the basis of equivalent grades for unequal traffic. This may be true not only as to grades in opposite directions, but also as to those in the same direction.

VIRTUAL GRADES.

Where a train passes over a grade at varying speeds, the virtual grade becomes a curved line. This results from the fact that train resistance and the power of the locomotive both vary with the speed. While this is true, virtual grades can better be understood if their consideration is first taken up on a basis of straight lines, such grade lines serving as measures of resistance. While train resistance is usually stated in the form of pounds per ton, it is frequently and conveniently expressed in the form of grade, and, as is well known, if the rate of grade per cent. be multiplied by 20 the result is the equivalent number of pounds per ton.

When a locomotive is hauling a load, the pull it exerts is frequently greater than that necessary to overcome the ordinary train resistances, even with curve and grade resistances added. The surplus pull, when there is any, acts on the train and accomplishes work whose equivalent is found in the increased energy of the train, and this may be measured by the increase in velocity. When the pull of the locomotive is less than what is necessary to overcome ordinary train resistances with curve and grade resistance added, there is a deficit in the amount of work done compared with what is required; this deficit is practically the same as a retarding force which accomplishes work, whose equivalent is supplied by drawing on the energy stored in the train; the loss of energy is measured by the loss of velocity resulting. A train starting at 25 miles an hour at the bottom of a hill and passing the summit at 7 miles an hour will require less pull to haul it than if a uniform speed be maintained, as is well known.

The actual profile is a matter of location and construction. The virtual profile introduces the element of operating; the latter depends in part on the actual profile and in part upon the speeds at which certain points are passed. At any station or point on the actual profile where the speed is specified, if the velocity head due to that speed be added to the actual height, it will give a point to be known as the virtual height at this station. The lines joining a series of points marking the virtual heights thus found show the virtual grades, and the profile thus constructed may be called the virtual profile.

The inclination of the line of virtual grade at any point is the true measure of the resistance which the locomotive must overcome as grade resistance. It must overcome this in addition to the ordinary train resistance, as well as the curve resistance, unless compensation for curvature has been used.

A momentum grade may be defined as a grade operated in such a way that surplus energy stored in a train is drawn upon to allow the train to be hauled up this grade, with less resistance to be overcome by the pull of the engine than would be necessary if uniform speed were maintained. The common case of momentum grades is that where the train passes the foot of a steep grade at comparatively high speed, and is allowed to pass the summit at low speed. The practical problem for the engineer engaged in location or construction is generally to determine either (A) how far a steep actual grade can be continued and yet allow a required virtual grade to be maintained, or, where an actual grade is under consideration, to determine (B) what the virtual grade will really be under prescribed conditions of operating, and also in this connection often to find (C) the speed which it is possible to acquire at the foot of a momentum grade.

Modern railway practice has substantially established the fact that momentum grades have their uses and are frequently of great value, but there are definite and well-known important objections to their indiscriminate use, and that they should be adopted as a matter of course ordinarily or wherever opportunity offers, especially in original location, may be seriously questioned.

The advantage of momentum grades is most apparent on short grades, or just where there is the best opportunity generally to reduce the actual grade. It should not be lost sight of that any grade lower than the limiting grade may at any time have value, due to the fact that many trains do not carry the same load throughout an entire division, but take on or set off cars at stations, with the result that any grade lower than the apparent limiting grade of the division may become temporarily, or even permamently, the real limiting grade, due to the greater loads hauled over it, and the lower grade may thus have the effect of increasing the capacity of the entire division. In revision of line, conditions of traffic and of operating are more definitely settled, and the use of momentum grades can be more intelligently made. It is often a choice between a momentum grade and the alternative of a lower train load over a division, if the grade in question is the real limiting grade of the division.

The proper procedure is for the engineer to note evidence bearing upon the matter from other similar features, to estimate in each case the advantages and disadvantages of the momentum grade, to take into account cost of construction and operating and to consider safety and convenience, and then, with these bearings in view, exercise his best judgment.

The principle of virtual grades finds an interesting application in connection with regular stopping points, such as stations on a railway where nearly all trains are local. The virtual grade being substantially uniform, the speed is decreased for trains approaching the station from either direction; in starting from the station the grade is also more favorable than the uniform grade, and any desired acceleration is acquired sooner.

At stations where many through trains pass, the only disadvantage would be a diminution of speed in passing the station, which is not altogether disadvantageous on the score of safety.

The subject has thus far been treated on the assumption that a straight line represents the grade up which the engine can haul its train. This is true only when the speed continues uniform. With higher speeds the tractive power of the engine decreases, and in addition the train resistance increases. The grade up which the engine can haul a given train is less at high speeds than at low speeds, and when the engine starts at a high speed and steadily decreases its speed, the line up which it can haul its train will be curved with the grade flatter at the beginning and steeper as the speed decreases. It is difficult and probably impracticable to directly apply this curved line to an actual profile. It may be possible to substitute for the curved line some straight line whose effect will make it a substantial equivalent for the curved line, but a simple solution in that direction is not an easy matter.

A somewhat different method of solution which is interesting and reasonably satisfactory is in use on the Canadian Pacific Ry., in the form of a diagram by which, in the case of a given engine and train, one can find for each grade the speed the train may acquire (or lose) in given distance, or vice versa the distance necessary to acquire (or to lose) any given speed.

(The committee then describe in detail the method referred to, which was given by Mr. A. C. Dennis in Engineering News of Nov. 22, 1900.—Ed.)

Any theoretical determination which depends upon both a curve for tractive force of engine and a curve (or straight line) of train resistance, must be subject to the criticism that even if the tractive power of the engine is reliable, yet on any particular railway the train resistance is likely to be different (often materially so) from that given by any of the well-known formulas or curves.

The series of curves shown in Engineering News Oct. 31, 1901, is even more conclusive evidence on this point. Nearly all of the lines shown in that diagram represent results of actual experiment on some railway at some time, and have extraordinary range. The work of finding the tractive power of an engine at varying speeds is also carried on at some disadvantage and inconvenience. There are two sources of possible error therefore in determining the surplus tractive force available for grade or for increased speed.

There would apparently be an advantage in point of simplicity in determining this surplus tractive force directly if a convenient means could be found for doing this. Fortunately it can be done by the simple expedient of critically observing velocities continuously during a run, in which the locomotive is handled with the object of securing reasonable uniformity and also thorough effectiveness in tractive force. The velocities must be properly connected with the actual profile of the road. Furthermore, for this purpose, the speeds must be observed with a degree of precision definitely greater than is commonly secured. In fact, it is probable that some special form of speed recorder would be needed for this purpose. The ordinary speed recorders in use would not serve the purpose.

The replies made to the inquiry of this committee in relation to methods of tonnage rating seem to indicate that the practical tests are seldom carried out with the addition of speed records. It reasonably follows that even when chief engineers and engineers of maintenance of way are opposed to the use of momentum grades, yet in practically rating the engines it is probable that in many cases a hill is actually climbed by using a higher speed at bottom and a lower speed at top. It is in any case desirable to know just how the steep grades are overcome, and careful speed records are essential for this purpose. On

some railways careful tests have been made both upon train resistance and upon the tractive power of the locomotive, and tests also as to speed in practical running test, and in such cases the ratings deduced have, in certain cases, at least agreed well with the practical road tests, as might be expected.

COMPENSATION OF GRADES FOR CURVATURE.

In computing from diagrams the speed a train will acquire at the foot of a grade where there are curves, an allowance must be made for the curves decreasing the grade. If curves are not compensated, this grade adjustment will be the total curve height allowance divided by the distance. If compensated, the grade adjustment will be twice as much, since the train will encounter both the curve and the flattening of grade also.

From the result of the committee's inquiries it would seem that the practice in this country at present favors compensation proportional to degree of curve, and 0.04 per degree represents average practice. The observation of the effect of compensation, however, seems on the whole not to have been critical enough to determine definitely whether or not it should be proportional to the degree of curve, and experiment and critical observation is further needed; the effect of curves as shown on a speed recorder capable of recording slight changes in speed is suggested as a desirable method of experimenting.

CONSTRUCTION WORK ON GRADE REDUCTION AND CURVE IMPROVEMENTS.

In the practical work of grade reduction, after the type of engine to be used has been settled, the rates of grade permissible decided upon, and the extent to which momentum and equivalent grades may be used has been determined, the location of the new work is the important question. This subject resolves itself naturally into three classes: (1) A new location far enough away from the existing line, to be treated as a separate line, and built according to the usual methods of construction independent of the old line; (2) raising or lowering the existing line on the original right-of-way and alinement; (3) a combination of the first two classes mentioned, in each particular section of work under construction. The third class is by far the most usual, and generally the most economical way, for the reason that it takes advantage of all available existing work, and only takes to a new alinement where required.

The experience of the engineers of a prominent line on which a large amount of grade reduction and change in alinement has been done has shown them that in grade improvements made for substantial distances it is better to build an entirely new line, and not interfere with the existing traffic in any way. That is, they appear to have succeeded in doing so for less money than by keeping the traffic moving over the existing line. A question of this nature, however, together with the extent to which an existing line may be disturbed and traffic impeded, must of course be decided for each individual case, the governing elements being the density of traffic or frequency of trains and the amount of saving reasonably expected from an intelligent comparison of the probable cost of each.

The various items to be taken into account in a tabulated comparison of the cost of the maintenance and operation of a new line with that of the old, as well as the method of pro-rating them, are so well understood that it is unnecessary at present to enter into details bearing upon them.

In the practical work of almost all grade improvements the steam shovel is usually the most important factor, and the committee endeavored to bring out for this report such facts as might be of use to those contemplating such work. To this end a series of practical questions were framed and sent to the members of the association in the form of a circular, and a brief digest of the answers received follows:

STEAM SHOVELS.—Shovels varying in weight from 35 tons to 80 tons, and in dipper capacity 1½ to 3 cu. yds., were respectively mentioned as desirable by various members, but the majority of the replies embraced opinions that a shovel weighing 65 tons, with a 2½ cu. yd. dipper, and at least 14 ft. clear height of dipper above rail, was the most serviceable shovel for general railway work.

SHOVEL TRACK.—Lengths of 4 ft. to 10 ft. were mentioned as being used, but over 50% of the replies advocate a length of 6-ft. sections for shovel track, fastened together with tie bars, and the rails joined with short splices, with one or two bolts each. Many replies stated that they used keys in place of bolts to fasten the short splices. One form of track mentioned has wrought-iron chairs on the joint ties, into which the rail ends fit. No splices nor tie bars are used with this particular track, and it has the advantage that a single piece of rail, say, 6 ft. long, is the heaviest thing to handle in moving up. Another form had the sections with tie bars resting on stringers 6 × 12 ins., and the stringers resting on ties and blocking as required.

Standard gage was recommended almost unanimously, generally because of ease of movement from place to place, and the ability to make use of tracks and sidings already laid. Two answers, however, recommended the 3-ft. gage, for the reason that cars were more easily handled on the dumps.

CARS.—There is considerable diversity of opinion in regard to the best form of cars, but the majority of the replies indicate that for rock or frozen earth flat cars, with aprons and stakes to be used with a plow, are the best. For trestle filling center-dump ballast cars were most approved, and for material which can be handled in them side-dump cars of from 14 to 20 cu. yds. capacity for use with plows seem most favored. Only a few advocate the use of small 5 to 7-yd. dump cars. All the replies received favor the use of aprons with all cars used with plows and cables.

UNLOADING CABLES.—Unloading with plows and cables seems to be very satisfactory to practically all who answered our inquiries, but a majority considered that the use of an unloader and not the locomotive was required, in order to secure the most economical working. The length given of cable proper to be used varied from 400 ft. to 2,000 ft. General opinion seemed to be that for use with the locomotive alone 20 cars were all it was economical to handle at one time, but that with an unloader 30, 35 or 40 cars, or whatever the locomotive could pull, were allowable in a train. Those favoring long trains stipulated that the train length should be shortened on a crooked road, and all advocated the use of snatch blocks on curves.

SPREADERS.—About 70% of the members who made reply use some form of spreader or bank leveler, but there is great diversity in the kinds used. There are principally two classes of such spreaders: (1) Those in which the wings open downward and outward, with hinges horizontal, and are handled either by a windlass or air pressure; (2) those in which the wings fold against the sides of the cars, with a vertical hinge near the front of the car. In this class the wings may be adjusted for height. Some of the second named class are reported very effective, but are a little slow for getting out of the way of trains. Those of the first named class, when operated by air from the locomotive, seem the best, because of the ease with which they can be handled. For quick work in grade reduction, it is essential that they have wings on both sides.

NEW EMBANKMENT.—The committee endeavored to ascertain between what limits various methods of making embankments were economical, such as raising the track on the filling material, the use of a central core put up by team work and widened with the shovel cars, the use of filling trestle, etc. In raising track on embankments it seems to be good practice to raise only about 9 ins. at a time, if the traffic is at all heavy; and even with very light traffic, not more than 12 ins. This method can, of course, be used to any height, but it ceases to be economical when a central core can be put up by team work, and all widening be done by shovel, without handling track so often.

Where banks are to be over 15 ft. in height, the temporary trestle for filling seems to be considered to give the best results. Instances are quoted where banks 40 ft. high, and built several years ago, are giving excellent results from the central filling trestle method. These banks were built of new material in the fall and winter and put into service in the spring. They have settled about 4 ft. in all, but the settlement has been uniform, and no tendency to slide has developed, although the material is mostly clay. The drop has no doubt been of considerable service in solidifying the mass, and it is thought that the piles of the temporary trestle work have also a good effect in steadying it.

Some of our members recommended the putting in of the base of embankments with teams, as this would obtain the necessary ditches. An ingenious method has recently been used on some very high fills. It consists of supporting a truss span, one end on the bank, and one end on a movable tower, and using a short train of cars to dump from the span and make the fill. The span is moved ahead as may be required.*

SHRINKAGE.—There can, of course, be no uniform rule laid down for allowance for shrinkage, as the required amount varies so greatly with the material. From 3% to 10% is a fair range, and it is recommended that allowance for shrinkage be made in width, as well as in height of banks.

W. McNab, G. T. Ry.; C. Dougherty, I. C. R. R.; H. J. Slifer, C. & N. W. Ry.; H. Baldwin, C., C., C. & St. L. Ry.; C. Frank Allen, Mass. Inst. of Tech.; R. C. Barnard, Penna. Lines; H. C. Phillips, A., T. & S. F. Ry.; W. D. Pence, Purdue Univ.; J. T. Wilson, P., C. & W. R. R.

Buildings.

The committee has selected from the topics assigned, two subjects for consideration at the annual convention of 1902, namely, "Coaling Stations" and "Water Tanks."

COALING STATIONS.

This term is applied to the appliances and conveniences which may been adopted for supplying locomotive tenders with coal. In its broader sense, it includes tracks, storage bins, derricks, hoisting engines, coal chutes, and all machinery connected with taking coal from cars in which it is shipped, and placing it in store for future use, or for delivering it either directly from the coal cars or from store to the engine tenders. The methods by which this work is accomplished are exceedingly various, and depend on a great variety of conditions which present themselves under different phases and combinations, and render the true solution of the economic equation almost impossible.

The principal factors for consideration may be enumerated as follows:

1. The question of location is one of the most important for consideration. This will be governed by the convenience as to the operation of the business of the railroad. At terminals and at junction points, if available that large coaling plants will be desired; but at intermediate points on the line, coal must be supplied to locomotives hauling freight and passenger trains. The location may determine largely the nature of the plant to be used. Where large quantities of fuel are to be supplied with only a limited amount of room for the construction of tracks and buildings, an expensive mechanical plant may be fully justified. At other points where the cars are small, a totally different style of plant may be the most economical.

2. The quantity of coal to be handled will also largely influence the character of the plant to be constructed. Where but one or two carloads of coal per day are required, it is doubtful whether anything but the simplest plant should be built that is sufficient to permit delivering the coal required in the least possible time. On the other hand, where from 200 to 400 tons per day have to be handled, expensive plants, well-designed machinery and first-class construction will be justified.

3. The cost of operation touches upon the labor question involving the consideration whether steam engineers, machinists and expert mechanics, or crude day labor shall be utilized in connection with the operation of the plant. In some parts of the country day labor may be had at approximately one-half the rates which are demanded in others. The rate of wages to be paid to the laborers will be an important item.

4. The amount of first cost, and also of the cost of repairs and renewals. It is evident that to make a true comparison of the economy of different plants, these items should be reduced to a measure of cents per ton of coal handled, rather than to make a comparison of the gross amounts of actual cost and of maintenance.

5. In the same connection, a true comparison will require a consideration of the interest on the cost of the investment, and this also should be reduced to an equivalent value of cents per ton of coal handled.

6. Complicating with all of the above is the question of storage. That this is a matter of great importance and that it usually receives but little consideration, is evident from the amounts which are annually spent in storing coal on coal cars, and holding the same on sidetracks at coaling stations, rather than constructing suitable storage bins in which the coal may be kept, thus liberating the cars for commercial business.

7. The kind of coal handled will also influence the decision—whether it be anthracite or bituminous, or both, inasmuch as the appliances which are efficient for one kind of coal may be less so for the others.

8. The facilities which each company has for delivering coal to its coaling plants will tend to make the situation more involved, since coal may be handled either in box cars, gondola cars (with stationary or with movable sides or traps), side-dumping or bottom-dumping cars and other varieties, each of which will have its own influence on the special modification of plant to be adopted for economy.

In order to determine what progress up to date had been made in the solution of this problem, your committee, with the assistance of the secretary, prepared a circular which was sent out to 225 railways all over the country, requesting information as to the "recent practice in the construction of coaling appliances."

A little over 40 replies only were received to this circular, and the general indication was that but little care was taken in filling the blanks, it being frequently understood that an attempt was made to get a description of all the coaling plants in use by any given road, rather than to describe the most recent or most approved plant. Very frequently no information was given as to the actual cost of operation. No questions were asked as to the cost of maintenance and repairs, etc., nor as to the original cost. It was, however, intended to ascertain, so far as possible, the actual cost of operation, and then that this cost should be distributed so that it might be shown whether, besides, the labor, fuel, supplies, etc., required in operation of a plant, there were included any items of cost of repairs and maintenance of interest, etc.

In general no details were given of the cost. Out of the replies received, 28 companies use coal chutes of one or another kind for the delivery of coal to their engines; 28 get the coal up to these chutes by means of inclines. A few have no better means of coaling tenders than to shovel the coal directly from the cars, or at least this is to be inferred from the fact that they do not list any better method. Less than one-fourth of the whole number have adopted any of the mechanical appliances for handling coal. A large proportion have no improved method for storing coal, and of these not all have any machinery for moving the stored coal either to chutes or to tenders for use. But very few make a practice of storing coal in any large quantities, but depend either upon storage in cars, or small piles placed either upon the ground or upon storage platforms as the only alternative to handling direct from cars through chutes or otherwise to the tenders. The statements of cost, as already alluded to, are very incomplete, and those that are given are somewhat indefinite. The rates named cover a wide range and but little can be learned from the study of the distribution given. It is not made entirely evident that the mechanical appliances for handling coal are always economical; in fact, the least rate at which coal is reported to be handled in any of these plants is where coal is delivered in dump cars, and is dumped directly to chutes, reported to cost only ½ ct. per ton for the delivery from cars to tanks or tenders.

Accompanying the replies to this circular there were transmitted a number of blue prints of various types of coaling plants, and the committee has selected from these certain general types which are illustrated by plates attached to the report.

*Engineering News, Jan. 16, 1902.

The Illinois Central R. R. has at 26th St., Chicago, a link-belt conveyor plant. Coal is delivered in either one or two track hoppers adjacent to the building. Preferably dumping cars should be used; ordinarily, however, a large proportion of the coal is shoveled from the cars. From the track hoppers, the coal is delivered to a conveyor by an automatic device, and carried up by a regular elevator belt with buckets attached to the top of the tower at one end of the coal-chute belting. This elevator delivers the coal to a conveyor which runs the whole length of the building in the cupola above the level of the chutes, descends at one end of the building, and passes through a small tunnel in the floor, ascending again at the other end. Tributary to the upper run of the conveyor are traps and spouts by means of which the coal is delivered into the ordinary coal chutes, of which there are 20 on each side of the building. From these it is delivered direct to the tenders. Surplus coal not required for delivery to the coal chutes is delivered into store, the whole bottom of the building beneath the coal chutes being constructed for storage. The bottom of the bin is nearly level. The coal is taken from store at the end of the pile wherever it may be in the building by lifting movable planking which covers the tunnel in the floor through which the conveyor travels. This coal is redelivered to the elevator, which, in turn, delivers it again to the upper section of the conveyor, from which it passes to the chutes. This plan has been in operation for approximately three years and accurate records have been kept as to the cost of its operation. It handles cinders and sand as well as coal. A summary of the cost of its operation for 18 months is as follows:

		Cts. per ton
Total tons of coal handled, 164,623:		
Wages of coal men unloading coal	$10,129	6.15
Repairs of machinery	1,452	.88
Wages of man operating steam engine	900	.55
Total cost	$12,481	7.58

The cost of handling coal should be considered also with reference to the other work done by this plant, and this involves a statement of the cost of handling cinders and sand. The following is a summary of this cost:

		Cts. per engine.
Cinders received from 56,240 engines:		
Wages of laborers	$1,811	3.22
Repairs of machinery	750	1.33
Total cost	$2,562	4.55
Cost of handling sand:		
Wages of laborers	$1,416	2.52
Repairs of machinery	116	.20
Total cost	$1,532	2.72

The folicwing general conclusions may perhaps be safely stated: In proportion to the amount of coal to be handled yearly, railway companies will be justified in the construction of more and more expensive coaling plants. The simpler types are inexpensive in first cost and in maintenance, but more expensive in operation; that is, in the cost of labor, and it would be feasible that, with accurate information as to cost of original construction, cost of operation and cost of maintenance, one could calculate with reasonable accuracy at what yearly rate of coal handled it would be economical to build mechanical plants; but the improvements which are being made from year to year in the details of construction and methods of operation of mechanical plants and the lack of sufficient data as to the items of cost above named make it impossible to give anything more than a general suggestion as to the point where the simpler should give place to the more complex mechanism. At present it seems probable that where a coaling station handles a yearly amount of 50,000 tons, a well-designed mechanical plant should operate economically, and this would be especially true if it should be desired to store any large proportion of the total amount of coal to be handled. The question of storage as already alluded to is a very vital one, and the importance of providing storage for coal is evident from the following considerations:

1. It is unsafe to depend entirely upon the daily delivery of coal in coal cars for engine use. The uncertainties of transportation, the danger of strikes at coal mines, and of strikes, riots and other disturbances to transportation, make it almost absolutely essential that some storage should be provided for. This in many cases is accomplished by having a surplus of coal in transit, or held in cars at or near the coaling station and at large terminals, where it may be readily available for the company's use, in case of emergency.

2. The expense of storage of this kind, namely, in cars either at coaling points or at terminals, foots up to an enormous figure, if we consider the average valuation, or equivalent daily rental of each coal car. The approximate cost of this service on the Illinois Central R. R. is estimated at upwards of $500,000 per year.

3. The coal cars in ordinary service are most in demand for commercial business during the fall and winter months, and it is desirable to store coal at points remote from the mines during the summer months when this equipment is not in such great demand, and when the output of the mines can be transported and stored without competition from commercial business. Where coal is stored in open piles, either on the ground or upon rough platforms, it is expensive to unload this coal at the outset, and still more expensive to reload the same and to deliver it to the coal chutes (or directly to tenders) as may be desired. This expense can be enormously reduced by the use of a proper mechanical plant.

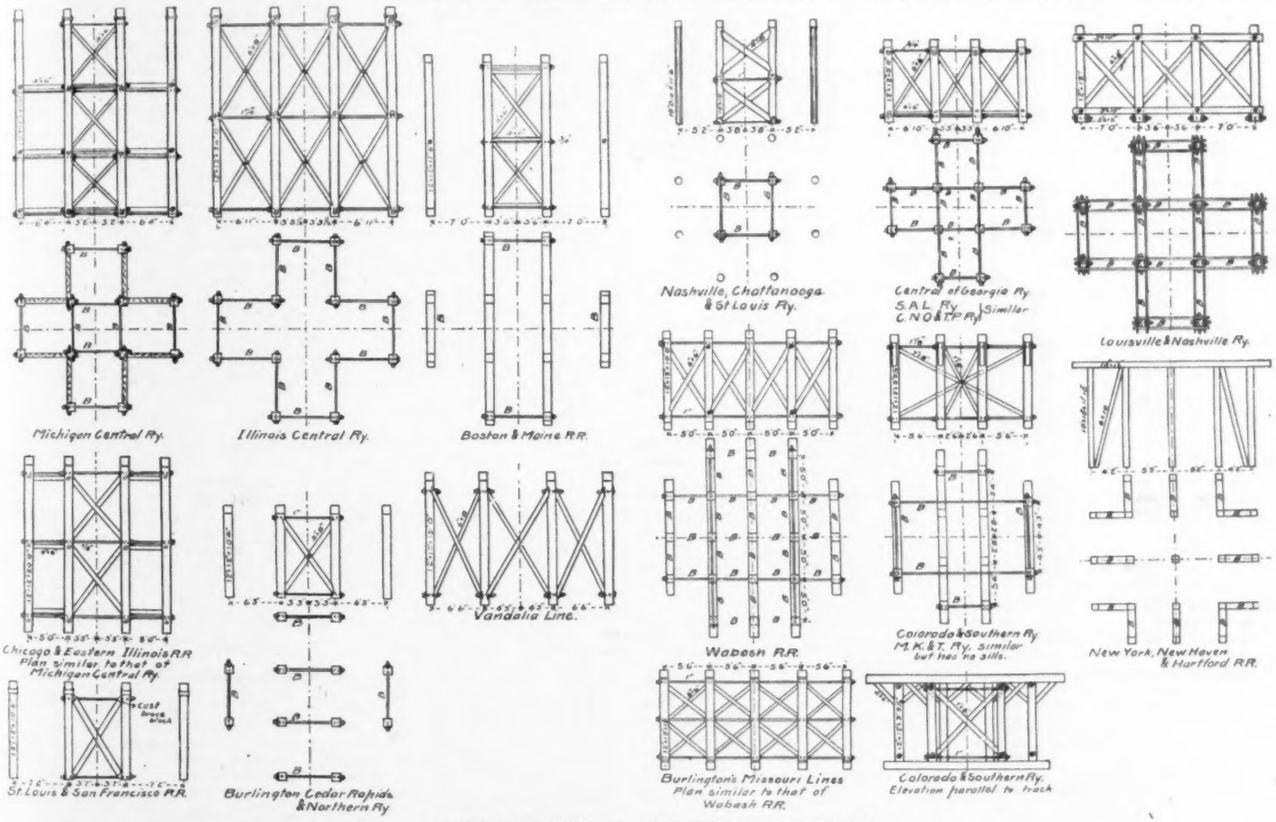
4. The deterioration of coal stored in open piles without protection is a very important consideration. Depending upon the climate and the amount of exposure, it is estimated that in a few months' time coal will lose from 10 to 25% of its value as fuel. This is partly caused by slacking or crumbling to pieces and partly by slow chemical change which goes on in the coal itself. The storage of coal in closed bins is frequently objected to on account of the risk from fire. It is believed, however, that, by taking the precaution to put only dry coal into store, and by designing the storage bins in such way that any portion of the contents may be drawn upon at will, also by providing means for determining whether the coal is heating, these objections may be overcome.

RAILWAY WATER TANKS.

In February, 1901, special requests for water-tank plans were sent to a large number of railroads, but plans were not received in time to permit the subject to be presented at the convention in March, 1901. The almost universal style of tanks now in use is a wooden tub 24 ft. in diameter and 16 ft. high, supported by 12 wooden posts. Most of the plans show tank located near the track and arranged to deliver water to engines by ordinary spouts, only three or four roads specifying that tank shall be placed at most convenient location and water delivered through water column.

Three plans show pile foundations; one cedar posts set upon cross-blocking about 6 ft. below surface; two circular stone walls extending up to bottom of tub; six stone cross-walls upon which sills or posts rest; 25 stone pedestals under each post; three concrete pedestals; two specify either stone or concrete pedestals; one stone or brick pedestal, and one does not specify foundations. Of the 16 plans specifying depth of foundation, 15 placed it at from 3 ft. 6 ins. to 8 ft. The Great Northern Ry. has radically departed from the usual aim of placing bottom of foundation below the frost line, and specifies one stone 3 ft. 6 ins. plan by 1 ft. thick under each post. The usual construction of tank frame is 12 posts of 12 × 12-in. timbers. All the plans show all posts vertical except for the C. & N. W. Ry. and F. E. & M. V. R. R. There are various styles of bracing used which are illustrated in the attached plates.

The tub in common use is 24 ft. in diameter and 16 ft. high. Four roads specify larger tubs. The Mexican Central Ry. has a standard metal tub, 20 ft. diameter, resting upon circular masonry walls. The Texas & Pacific Ry. uses a tub of corrugated galvanized steel, supported upon wooden frame. The chief engineer of this road states that he finds it more satisfactory than a wooden tub in the arid and semi-arid regions traversed by the Texas & Pacific Ry. and seemingly just as satisfactory upon any portion of the line. He says the cost is about the same as for a wooden tub. The plans give quite a variety


Michigan Central Ry.
Illinois Central Ry.
Boston & Maine R.R.
Nashville, Chattanooga & St Louis Ry.
Central of Georgia Ry.
S.A.L. Ry.
C.N.O.&T.P. Ry. Similar
Louisville & Nashville Ry.
Chicago & Eastern Illinois R.R. Plan similar to that of Michigan Central Ry.
Vandalia Line.
Wabash R.R.
Colorado & Southern Ry. M.K.&T. Ry. similar but has no sills.
New York, New Haven & Hartford R.R.
St. Louis & San Francisco R.R.
Burlington Cedar Rapids & Northern Ry.
Burlington's Missouri Lines Plan similar to that of Wabash R.R.
Colorado & Southern Ry. Elevation parallel to track

UNDER-FRAMING FOR RAILWAY WATER TANKS.

of roof designs. The accompanying plates of small scale drawings show about half of the plans obtained.

The discharge pipe varies from 6½ to 12 ins. diameter. The height above top of rail of track end of goose-neck varies from 10 ft. 3½ ins. to 14 ft. 9 ins. Nine plans show overflow pipes varying in size from 2 to 6 ins. Among the plans presented, none are given of iron or steel tanks, a form of construction which is now coming into use, and which may supersede eventually the construction of wooden tanks. Tanks of this kind are in use in several places by railway companies which are represented among the membership of the association.

H. W. Parkhurst, Ill. Cen. R. R.; A. R. Raymer, P. & L. E. R. R.; A. S. Markley, C. & E. I. R. R.; C. T. Norton, Mex. Int. Ry.; B. C. Gowen, Wis. & Mich. Ry.; E. C. Macy, C. G. W. Ry.; H. W. Cowan, Colo. & So. Ry.

MEASURING CLOUD DISTANCES FROM A RAILWAY TRAIN.

By M. Am. Soc. C. E.

The wonderful cloud effects in the western prairie states offer some compensation for the absence of mountain ranges and lofty summits. Strangers have frequently been deceived, and old residents greatly surprised by the close resemblance in form and gradations in color. At other times the "were-wolves" and "swan maidens" fully establish and maintain the well-known claims of the mythologists. Not infrequently the cloud surface becomes a map, showing well-defined boundaries for land and sea; here the Straits of Gibraltar and a bit of the Mediterranean, there an island with a harbor not to be excelled. With such displays there comes to the observer the same questions that were asked and unanswered when he was a child: "How far away are those mountains?" "What is the distance from that sharp peak to the one across the rugged valley?" "What scale fits this map of the sky?" "Could a frigate enter that harbor?"

Not "he who runs," but he who rides, can now read with great exactness the answers to these questions. When large expenditures of money and time effect certain desired and well-defined results it awakens a keen feeling of satisfaction. So it does, too, when a number of different things, each intended to serve its own particular purpose, bear such relation to each other that they may serve an entirely different purpose, and one not thought of at first. To this order or class belongs the answer to the cloud questions. A brief description of the conditions that are involved will first be given, to be followed by the method of determination.

The spacing of the ordinary telegraph poles upon the different railways depends upon the number of wires or weight that they have to sustain, as well as upon their size, and ranges from 30 to 40 or 45 to the mile. But since the roads are usually provided with mile-stones the distance between the telegraph poles can be readily and accurately ascertained, and is uniform for long intervals.

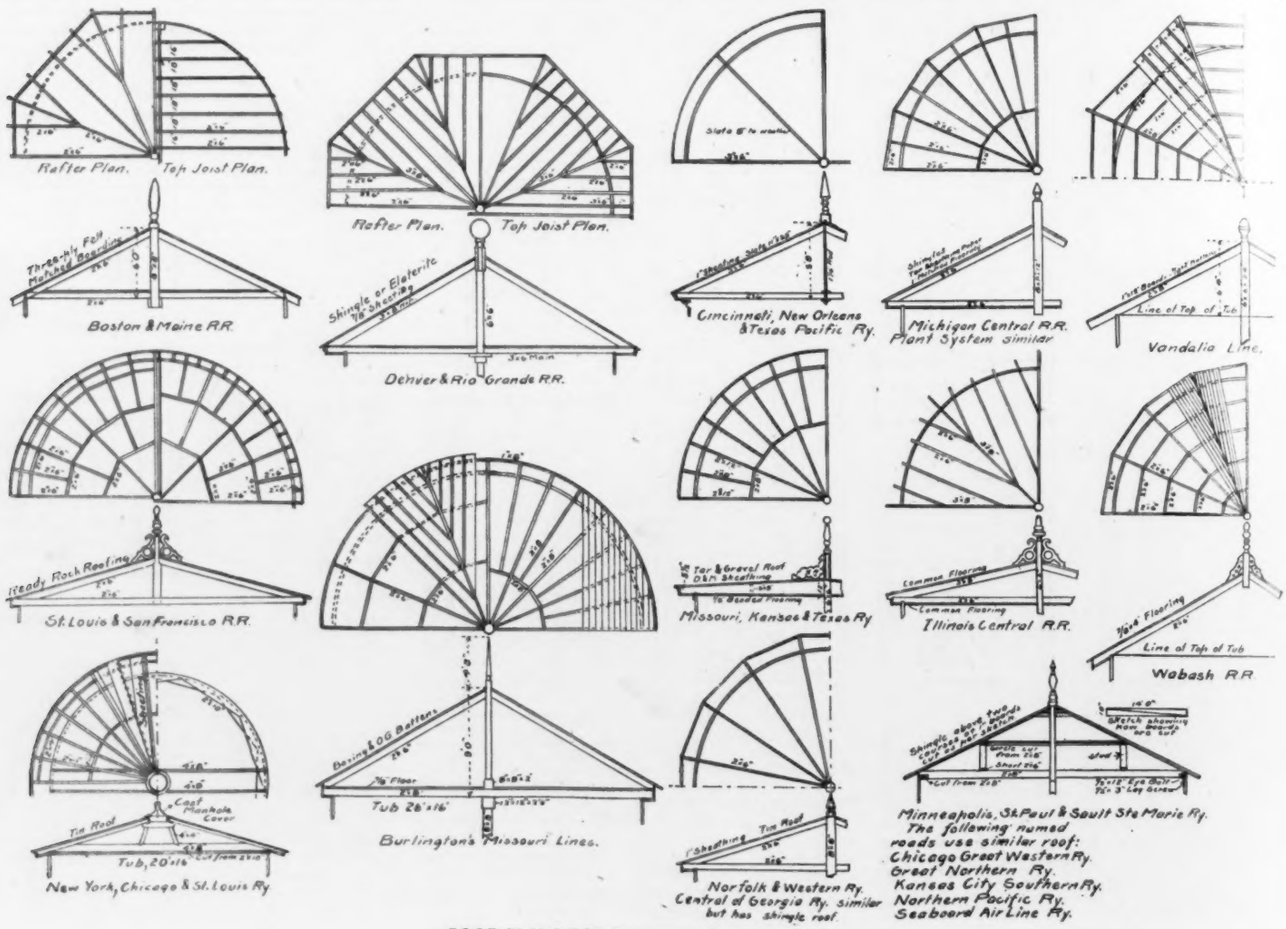
The long as well as the shorter tangents upon all first-class or trunk line railways are laid down with the greatest care, and are approximately true and straight lines. Very little work is done in "throwing track" unless the extent of the movement has first been defined by the stakes of the engineer. With the modern heavy equipment great care is also exercised to maintain the correct height of each rail and make a level roadbed.

The recent improvements in platforms and the complete vestibuling of trains insures the maintenance of a car very closely in its proper position in a train; that is, the axis of the car coincides accurately with the axis of the train. This may be shown by watching the behavior of the platforms and vestibule connections when a train is in motion. The glass used in the ordinary Pullman or drawing-room car is generally of excellent quality, and transmits the light with very little refraction.

In making practical application of these various facts it is convenient, though by no means necessary, to have some little acquaintance with the character of the road in question so as to know where tangents of some length occur. The traveler should first determine the distance between the telegraph poles by determining the number per mile as indicated by the mile-stones. He should also note a favorable condition with respect to clouds, and whether they have a perceptible motion due to the wind, and this he can ascertain by close observation for a moment when the train is at rest. Then at the top of a convenient window he should fix upon the glass two spots, bits of a postage stamp large enough to be visible across the car will do. These spots should be spaced a given horizontal distance from each other, say 1 ft. Against the opposite side of the car the traveler may then rest his head in such a position that the first of the above-mentioned spots, that is, the spot nearer the engine, comes in a line with his eye and some well-defined point upon the cloud surface. Then maintaining his position steadily he will observe that this spot appears to move steadily and uniformly across the cloud-sky. At the initial moment he will note the passage of a telegraph pole past the line of vision, numbering it zero, of course, and continuing the count. Gradually the second spot on the window pane in its horizontal movement approaches the point upon the cloud surface which had been first observed, and when it coincides exactly with this point the count ceases.

Let it be supposed that 80 poles have been passed in this interval of time, and that the spacing of the poles had been ascertained to be 150 ft. This would give 12,000 ft., as the observed distance between the two points of observation as projected against the sky, and this immediately becomes a unit of measure for the determination of cloud dimensions at the observed elevation.

The distance of the cloud itself from the point of observation may be quite accurately de-


Rafter Plan.
Top Joist Plan.
Boston & Maine RR.
Rafter Plan.
Top Joist Plan.
Denver & Rio Grande RR.
Cincinnati, New Orleans & Texas Pacific Ry.
Michigan Central RR. Plant System similar
Vandalia Line.
Ready Rock Roofing
St. Louis & San Francisco RR.
Missouri, Kansas & Texas Ry.
Illinois Central RR.
Wabash RR.
Burlington's Missouri Lines.
Tub 26'x16'
Tub, 20'x16'
New York, Chicago & St. Louis Ry.
Norfolk & Western Ry.
Central of Georgia Ry. similar but has shingle roof
Minneapolis, St. Paul & Sault Ste Marie Ry.
The following named roads use similar roof:
Chicago Great Western Ry.
Great Northern Ry.
Kansas City Southern Ry.
Northern Pacific Ry.
Seaboard Air Line Ry.

ROOF PLANS FOR RAILWAY WATER TANKS.
Scale; ⅛-in. = 1 ft.

termined by noting the width of the car, if the full width were used, which will be found to be about 9 ft. from the eye of the observer to the window, and with the assumed spacing of 1 ft. nine would be the ratio for determining the actual distance (12,000 × 9 = 108,000). It may be noted that this result is obtained as precisely as it would be if the traveler had been seated upon the cloud and made observation upon two points on the earth 12,000 ft. apart, with vertical stadia lines in a tube 9 ft. long. The accuracy in this will be apparent to any one accustomed to stadia measurements.

It is well known that in a flat country the distant horizon closely coincides with a level line at the point of observation. A measurement from one of the points above referred to down to the level of the horizon, and the use of this measurement in a simple calculation insures a fairly accurate determination of the height of the cloud that has been observed.

As often happens when the truth is applied to subjects about which we are somewhat in doubt or a little hazy, curious results follow such observations. The comfortably disposed "swan maiden" near the horizon may prove to be eight or ten miles in length, while the channel in the cloud map that seemed to the imagination wide enough for a fleet, would scarcely permit the entrance of a torpedo-boat destroyer. Besides it may be of passing interest to the engineer to think that the skilful and accurate work done upon the surface of the earth can be noted, even though fleetingly, at a higher elevation.

In the accompanying diagram, Fig. 1, let the irregular outline E A B represent a portion of a car in the position it occupied at the commencement of the determination, and the figure E′ A B represent its position after the determined distance of 12,000 ft. had been passed over. The points A and B are fixed, as above described, upon the window. C represents a well-defined cloud point. Now, by reason of the movement of the car, the line E C advances to the position of the dotted line E′ N and the line E M to the position of the dotted line E′ C. The distance between C and N or C and M thus becomes known by direct measurement as 12,000 ft., the distance passed over by the car. This becomes the unit of measure or scale by which dimensions of neighboring clouds and spaces of clear sky may be determined with a fair degree of accuracy.

The lines E M and E¹ C are parallel, and are intersected by the straight line E C. By geometry we know that the angle E¹ C E is equal to the angle C E M or A E B, thus giving all the data necessary to determine with theoretical exactness the distance E C.

In Fig. 2, let E A represent a vertical section of the car; C the position of the cloud and H the horizon. Then a line from the eye of the observer to the horizon may be supposed to leave the window at the point P, at some distance below the point A, first fixed upon the window, which distance can be determined by measurement, and may be called K. The distance E C being known, the distance C H would be roughly indicated by the expression E C × K ÷ 9, thus giving approximately the elevation of the cloud above the surface of the earth.

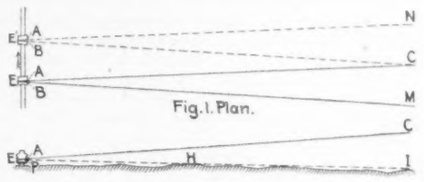


Fig. 2. Elevation.

Diagram Illustrating the Measurement of Cloud Distances from a Railway Train.

It might be remarked that on account of the slight rolling and vibratory movement of the car there will be some shifting movement of the point upon the window as projected against the sky, in much the same way that a slight wind interferes in turning angles with a transit. But every engineer knows that fairly accurate work can be done under such circumstances by selecting approximately such a position for the staff that the cross line vibrations will be of about equal extent upon both sides of it. The same principle controls in this case. An observer may be surprised by the steady movement of the projected point upon the surface of the clouds, and by the rapid movement, too, when the clouds are comparatively near. The time required for such a determination is, of course, very brief, inside of two or three minutes when a train is running at a fair rate of speed.

HIGH CONCRETE PIERS FOR RAILWAY BRIDGE ACROSS STONE'S RIVER; TENNESSEE CENTRAL RY.

We illustrate in the accompanying cuts the concrete piers recently built to carry a three-span bridge across Stone's River, on the Tennessee Central Ry., near Nashville, Tenn. These piers were designed to carry a channel span of 200 ft., and two side spans of 65 ft. each, and they are each 65½ ft. from the bottom of the foundation to the top of the coping, which places them among the highest solid concrete bridge piers ever constructed. The Chief Engineer of the Tennessee Central Ry. is Mr. F. M. Bisbee, and the piers were built by Mr. Franklin G. Power, Civil Engineer and Contractor, of Atlanta, Ga. We have received the following description of the work from Mr. Power:

The piers supporting the channel span, as shown in the illustrations, are 63 ft. 6 ins. from bedrock, upon which they are built, to bottom or coping, and they have a coping of concrete 2 ft. thick, making a total height of 65 ft. 6 ins. from foundation to top of coping. The size under the coping is 24 ft. × 8 ft., and the sides are constructed with a batter of half an inch to the foot. The piers were built as follows: 1 part of Old Dominion Portland cement, furnished by the Hartranft Portland Cement Co., of Philadelphia, Pa.; 3 parts of clean sharp sand, and 5 parts of broken stone to pass through a 2-in. ring.

The work was constructed in forms which were built up as the work progressed. The concrete was placed in 6-in. layers and tamped thoroughly until the water began to rise upon it and it began to quake. The work was carried on from day to day as any other stonework would be, only in cases of rain or freezing weather, the last course which was put on at night was thoroughly cleaned of any loose or damaged cement and then primed with neat Portland cement before laying concrete the next morning. The work when completed showed a monolithic mass, and after, having set for three months, "rings under the hammer" like solid rock.

The coping and 2 ins. of the exterior surface of the piers were formed of a concrete made in the following proportions: 1 part Old Dominion Portland cement, 2 parts of sand, and 4 parts broken stone to pass through a ¾-in. screen. This was put in place by using a slip-board between the interior mixture and the outer forms and pulling out this board after placing this mixture, then tamping the whole to make a perfect bond. Both the interior and exterior mixtures were carried up evenly at the same time in 6-in. courses.

Fig. 1. View Showing Completed Pier and Timber Forms for Pier Under Construction.

Fig. 2. View Showing Completed Pier and Hand-Propelled "Stern Wheeler" Used for Transporting Men and Material.

FIGS. 1 AND 2. CONCRETE PIERS FOR 200-FT. CHANNEL SPAN OF TENNESSEE CENTRAL RY. BRIDGE ACROSS STONE'S RIVER, NEAR NASHVILLE, TENN.

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The third annual convention of the American Railway Engineering & Maintenance of Way Association, which was held in Chicago last week, by its attendance and the general interest manifested promised well for the future development of this association, but indicated also that the Board of Direction needs to pay still more attention to the organization and work of the association's committees. The technical work of this association is done through 15 standing committees, only two of which failed to report, but the 13 reports presented were of very varying character and quality. Some few were really the work of committees which had held regular meetings for the discussion of their particular subject. Others were largely compiled from correspondence, others were compiled from the work of sub-committees, and still others were one-man reports. Those of the last type, as well as some of the others, developed, when presented, considerable differences of opinion among the members of the committee.

Some impatience has been expressed at the slow progress made by the association in the adoption of standards and recommendations, and it has been urged that unless such action is taken the reputation of the association will suffer. Such criticisms, however, are ill-advised. The association is young, and it will be wise to make haste slowly in making formal recommendations and adopting standards, especially in view of the hurried preparation of some of the reports. When we consider the work of the other and older associations of similar character, it will be very easily seen that such action, where it means anything, has followed long and careful investigation. The difficult work for the next few years will be in organizing committees whose members will undertake the work expected of them, and in regulating and controlling the work. In the past, the committees have been composed of members selected from various parts of the country, for the special purpose, as stated by the President at the meeting, of arousing general interest. While this object has been accomplished, this plan has the objection of making it difficult for the members to attend the meetings of their committees. One committee, with a chairman in the west and a vice-chairman in the east, adopted the plan of holding separate meetings under the direction of both the chairman and the vice-chairman, the reports of proceedings of these meetings being sent to all members. The President intimated that in future the plan will be to follow this plan generally, but to localize the members of each committee, so that they will be within convenient reach of one or other of these officers.

We are strongly inclined to doubt the wisdom of the plan thus far followed by this society of confining its technical proceedings to the presentation and discussion of reports by its standing committees. The "committee report" plan of work has been largely adopted by technical societies in the railway field; but we know of absolutely no reason for this except the conservatism that clings to past precedents. When railway technical associations were first organized it was virtually impossible to get individual members to present formal papers, and somebody hit on the scheme of appointing committees to report on various topics, in order to fill up the program, and present subjects in form for discussion. That system has been perpetuated in all the railway organizations since, and it is time that some of these societies woke up to its defects and accumulated sufficient independence and originality to abolish it.

Let us say at once, however, that we have nothing at all to say against the committee plan of work, where the work is actually demanded and done. What we condemn is the committee report, which is in reality entirely the work of one man, and to which the rest of the committee attach their names in a perfunctory way. Such a document is not what it purports to be. It fails on the one hand to give its real author the credit which is his due; and on the other hand it sends out to the profession one man's opinions and ideas, under the guise of a consensus of opinion. We do not exaggerate when we say that the majority of the reports before the railway associations are prepared in the way above set forth.

If the Maintenance of Way Association would reduce by one-half the number of its standing committees and set the remaining half (with, perhaps, some special committees appointed to report on a definite subject) at work in limited fields, it would improve the character of its work.

The loading of freight cars to their full carrying capacity is well recognized as tending to an important economy in transportation, and various methods of ensuring full loads have been devised by railway companies and associations. A somewhat serious obstacle, however, which is not generally understood by those not familiar with the traffic and transportation departments of railway service, lies in the fact of old-established customs in loading, which in a way resemble the various local weights and measures which were so troublesome until a few years ago. As will be seen by a discussion quoted in another column, there are "commercial" carloads established by custom without regard to car capacity. Thus, so many barrels or bags of a commodity are considered as a "carload," although they give the car but half its rated capacity, and considerable difficulty is experienced in persuading shippers to load larger quantities per car, because in so doing they depart from the custom. It is certainly a curious and incongruous situation that at a time when railways are increasing their car capacity and there are numerous complaints of a car famine, shippers are regularly taking two cars to carry a load which might readily be carried in one car, with benefit to all concerned.

The advantage to the public, as well as to the railways, of co-operation among the different companies to remedy abuses of this sort is too obvious to require proof. As noted elsewhere, an increase in the minimum carload weights of grain products has already been ordered by the Official Classification Committee.

The contribution printed elsewhere in this issue upon determination of cloud distances was not received during the most favorable season of the year for such observations in this latitude. The quiet autumn or Indian summer days usually offer better opportunities than those of early March, nevertheless some of our readers in distant lands may peruse the article under conditions favorable to experiment.

It is evident that the method described may be applied also to the determination of distances from the car to objects in the landscape, such as a well-defined mountain peak or spire or structure of any sort upon the horizon, and at right angles to the line of travel.

Our contributor, on request, supplements his paper with a simple geometrical explanation of his method, which is closely related to some of those used in astronomy, where the observations are not carried forward and guided by artificial forms. It might be difficult, however, to cite another instance, except in observatory work, where one traverses and measures a base line, and at the same time measures the opposite angle in the triangle of which the base line is a part.

The latest argument against the use of water meters, which is at the same time a highly original contribution to our knowledge of all those bacteria conveniently classed as "disease germs," is the joint product of a citizen of Minneapolis and a Cleveland newspaper. As we have recently recorded, the present authorities of Cleveland have entered upon a vigorous campaign for the introduction of water meters. The Cleveland "Leader" has published a letter "from a man in Minneapolis" who proposes to remove to Cleveland, stating that in Minneapolis the water meters

> form a hiding place for all the disease germs which may be in the water, and that the meters become foul with vegetable and organic matter very often if there is no way to flush them.

A person with a vivid imagination can picture disease germs not only hiding, but also playing hide-and-seek, or even tag, in water meters. In commenting on this alleged new danger from water meters, the editor of the "Leader" says:

> At least Superintendent Bemis should get an expert opinion, if possible, that will reassure the people.

It might be well to have the expert give an opinion, also, upon the probability of the bacterial antics suggested above causing over-registration of the meters!

In discussing the placing of responsibility for accidents, in our issue of March 13, we alluded to the official investigations of boiler explosions which are made in Great Britain under the direction of the British Board of Trade. We find summaries of two such recent investigations, in the "Board of Trade Journal" of March 6, and it may be of interest to give an account of them here. The first case was a boiler on the steamship "Dungonnell." The vessel had been undergoing a survey, and after its completion a sludge-hole cover was put on with round packing, of ¾-in. diameter. Two days later steam was raised and at 50 lbs. pressure part of the packing around this sludge-hole blew out, filling the engine and boiler rooms with steam and scalding to death two firemen. The court decided that the explosion was due to the neglect of the Superintending Engineer, in making the joint with round instead of flat packing; but in view of the common use of such packing, the court acquitted him of blame. At the same time, they called attention to an explosion in 1898 due to the use of round packing, and intimated that in case another explosion from this cause should occur, the person responsible for the use of round packing could not be held free from blame.

The second case investigated was an explosion on a locomotive operated by a coal mining company. The copper fire-box bulged inward, pulling off seven stay-bolts, and the engine-runner and fireman were scalded. The court found the ex-

plosion to be due to the fire-box being improperly stayed, and also that the supervision of the boiler was not satisfactory, no one person being responsible for repairs to locomotives.

The court found that the explosion was contributed to by the neglect of the foreman boilermaker, colliery enginewright, colliery manager, foreman fitter, and engine fitter, and for this neglect the company was responsible. They further ordered the company to pay the sum of £50 towards the cost and expenses of the investigation.

The division of responsibility on which we laid stress in our article of two weeks ago is well illustrated in this second case above noted, and the first case admirably illustrates our contention that official investigations to determine the cause of accidents are urgently needed. The lesson of this accident is to avoid the use of round packing, and the public record of this by the official investigation makes this lesson available to all who will heed it. Under our American system, however, hiding and keeping secret every detail connected with an accident, most of these "teachings of experience" are forever lost.

A BIRD'S-EYE VIEW OF CONDITIONS IN THE IRON AND STEEL INDUSTRY.

For many years the "Directory of the Iron and Steel Works of the United States," issued at biennial periods, has been the standard work of reference in its field. The last edition was issued in 1898, and a new edition was due, therefore, in 1900. But when the time came to collect the information for a new edition, the iron trade of the country was in a condition of upheaval without precedent in the annals of industry. Consolidations, options and deals of every sort were the order of the day. No man was prepared to give information concerning works which might a week hence be transferred to another firm. It looked at one time as if consolidations were to continue until the entire iron and steel industry of the country would come under the control of a single mammoth corporation. In 1901, however, there came a lull in the progress of consolidation, and it became evident that the industry had reached a condition of at least temporary stability. Work on the preparation of the Directory was, therefore, resumed; but there were still so many changes in progress that the book which was at first intended to be issued by Nov. 1, 1901, was not actually published until the first of the present month.

Few men, unless they are closely connected with the iron industry, have kept in touch with all the changes which the consolidations, heralded in the newspapers from day to day, have finally created. It is of no small interest, therefore, to obtain, by means of the book before us, a bird's-eye view of the iron and steel industry; and to compare the present situation with that of four years ago.

Undoubtedly the question of greatest interest relates to the position which the United States Steel Corporation has attained. To what extent has it secured the monopoly which it aimed at? How far can it go in compelling purchasers of iron and steel to accept the prices and terms which it makes?

Notwithstanding all the fine-sounding deliverances of United States Steel officials, concerning their philanthropic intentions we have yet to see the purchaser of iron and steel who did not prefer to rely on competition to protect him from the exactions of the monopoly. If the United States Steel Corporation controls the whole industry, it can charge what prices it pleases for its products and tax the public indefinitely whatever it needs to pay dividends on its enormously watered stock. If, on the other hand, there is a considerable number of outside producers, there will be some chance for competition to bring prices back to a reasonable figure at no distant day. Therefore, the question what producing capacity is still outside the Steel Corporation assumes very large importance.

Turning to the book before us we find the first 68 pages devoted to the record of the U. S. Steel properties. Then follows 83 pages devoted to the record of other consolidations. Farther on in the book, in the complete list of furnaces and mills, is found ample evidence of the extent to which new iron manufacturing enterprises have been pushed forward during the past two years.

It may be of interest to briefly enumerate some of the very large producers of rolling mill products which are outside the United States Corporation. Taking them in the order given in the book, we have, first, the Republic Iron & Steel Co., with 6 blast furnaces, 27 rolling mills and steel works, and a total annual capacity of over 1,000,000 tons of rolled and forged products. Next comes the Lackawanna Iron & Steel Co., with old works at Scranton of nearly a million tons capacity and new works at Buffalo, soon to be put in operation, designed to be the equal or superior of any plant in existence in economical production, and to have a total capacity of 1,250,000 tons. Next are enumerated a number of comparatively small concerns: The Phoenix Iron Co., the Glasgow Iron Co., the American Iron & Steel Manufacturing Co., the Susquehanna Iron & Steel Co., and the Lukens Iron & Steel Co. The total annual capacity of all these will amount to nearly a million tons of rolled or forged products. Next comes the Pennsylvania Steel Co., with a possible output of about 800,000 tons, at its two works at Steelton and Sparrows Point. Then comes Cambria with over 600,000 tons output, and then the old firm of Jones & Laughlin's with 725,000 tons.

Next are enumerated some formidable new competitors in the Pittsburg district. The St. Clair Steel Co., has works nearly completed on the Monongahela, 20 miles above Pittsburg, which will be able to turn out 300,000 to 350,000 tons. The Sharon Steel Co., with its entire plant built since the organization of the United States Steel Corporation, can turn out 300,000 tons of rolled products, is an active competitor in the wire industry, and is building a wrought-pipe plant of 120,000 tons capacity. The Wheeling Steel & Iron Co. can produce from its four rolling mills some 375,000 tons, and is also building a new tube mill, of 75,000 tons capacity.

Of concerns in more remote sections of the country we may note the Tennessee Coal, Iron & Railroad Co. and the Colorado Fuel & Iron Co., with an aggregate capacity of perhaps 700,000 tons.

A rough addition of the above figures shows that the companies above enumerated, all of which are outside the United States Steel Corporation, have an aggregate annual capacity of over 7,000,000 tons of rolled and forged iron and steel products.

But this by no means tells the whole story. The concerns listed above are only those which have been listed by the editor of the book before us, under the head of "consolidations." While this list includes the "giants," the detailed list of furnaces and rolling mills shows a large number of small concerns whose aggregate output amounts to a very considerable figure. And with the attacks of these Lilliputians, as well as of their large brethren, Gulliver will have to reckon when the test comes.

There is, of course, nothing surprising in all this. During the past four years, well-located and well-managed works in every branch of the iron and steel industry have been making enormous profits. The demand has been so great that the product has been sold with little trouble and expense. Such conditions were bound to stimulate the building of blast furnaces and steel works and rolling mills; but in addition other influences were at work. A huge amount of new capital was poured into the steel industry by the financiers who effected the recent consolidations. Not a small amount of this capital went into the pockets of men who immediately set to work to invest their money in new works to compete with those which they had just sold. Nor did these men lack financial assistance. Money for new steel enterprises has been easy to obtain, and the desire of banks to secure new customers to take the place of those whose plants had been swallowed by the combine has made the financing of these new enterprises an easy task.

Another most potent cause has operated to foster the building of iron and steel works. Among the largest users of iron and steel are great and wealthy manufacturing concerns, and these have not relished the prospect of entire dependence on a monopoly for their raw material, no matter how ably such a concern might be managed. Not a few such concerns have quietly made provision against future contingencies. There has been a notable tendency among firms which formerly purchased steel in partially finished forms to provide their own furnaces and blooming mills or else to secure an interest in some independent plant which could be controlled in case of need.

As we stated above, the last preceding issue of the Directory gave figures for April, 1898. The present edition gives figures for November, 1901. At the first-named date the annual capacity of the blast furnaces of the United States was set at 18,000,000 gross tons. At the present time this capacity has been raised to 24,000,000 tons, an increase of one-third in less than four years. In the steel mills the capacity of Bessemer converters has been raised from 10,633,000 tons in 1898 to 13,000,000 tons in 1901, while the open-hearth furnaces show the astonishing growth from 3,500,000 tons in 1898 to 8,300,000 tons in 1901.

The question which is universally asked is, how long will the present enormous and abnormal consumption of steel continue? We have to go no further back than the four years from 1893 to 1897 to find a time when a producing capacity less than three-fourths that existing at the present time was largely idle for lack of demand. Doubtless a steady increase in consumption of iron and steel is to be expected; but the sudden jump from the stagnation of 1897 to the boom of 1901 is not natural growth, but temporary and extraordinary fluctuation. To every such action there must certainly succeed a reaction, which, if not exactly "equal and opposite," as described in the textbooks on mechanics, will yet be measured in intensity by the height reached in the first movement.

There is still another reason why supply and demand must soon be equalized in the iron trade, and that is the rate at which productive capacity is still being augmented. The Directory gives a summary which shows that on Nov. 1 last there were in the United States 12 blast furnaces under construction, while 7 more were projected. There were also no less than 28 rolling mills and steel works in process of erection, while six more were projected. In open-hearth steel manufacture the whole United States showed 403 furnaces completed and 46 under construction, or enough to increase by nearly one-eighth the annual output of this class of steel.

Certainly with such huge additions to producing capacity, it can be no long time before the supply of steel will again be in excess of the demand. Under such conditions, with mills hustling for orders, and buying falling off (as always happens on a falling market), what can prevent prices and profits in the iron and steel industry returning to a normal basis?

We do not say this will happen at once. Very likely the Steel Trust and its competitors will form pools to restrict production and maintain prices as long as possible; and further consolidations may take place. So long as these abnormal prices and profits continue, however, so long will there be found men ready to build works which can either be run so as to pay for themselves in a very few years, or else can be sold to the trust at a large advance on their cost. The trust cannot indefinitely pursue the plan of buying out its competitors at an abnormal price, and watering its securities to pay the bill. Sometime the process of dilution must come to an end.

Even if it were possible, moreover, for the United States Steel Corporation to maintain an absolute monopoly, it is not believable that the public would long endure such a condition. The public opposition to the huge consolidation has by no means been removed. It has only been temporarily disarmed, partly by the fact that the monopoly has not yet made use of its power to interfere with the natural course of prices, as determined by the laws of supply and demand and partly by the knowledge that outside competition has by no means been eliminated from the steel industry. If these conditions change the public will certainly find means to protect itself.

LETTERS TO THE EDITOR.

The Construction of the Forbes Hill Reservoir and Stand-Pipe at Quincy, Mass.—Correction.

Sir: On page 219 of your paper of March 13, 1902, appears a table of sizes of sand boxes and stone boxes, which kindly explain. What are the depths of the stone boxes, and are the boxes proportioned to the amounts given in Table II., or are they intended for batches of four bags of cement? Also in Table II. should not class A read: 1:2½:4? Yours truly,

Olaf Helweg.

Navy Yard, League Island, Pa., March 17, 1902.

(We have received from Mr. C. M. Saville, M. Am. Soc. C. E., author of the article in question, the following answers to the questions asked by Mr. Helweg.—Ed.)

Sir: The stone boxes were 8 ins. deep and were proportioned to the amounts given in Table II., i. e., for the Class "C" mixture, 1:2:5. The quantity of stone per batch or barrel of cement was 3.7 cu. ft. (specified contents of a cement barrel) × 5 = 18.50 cu. ft. The gage for this quantity of stone was 5 ft. long, 5 ft. 6⅝ ins. wide (instead of 6 ft. 6⅝ ins., as given in the text) and 8 ins. deep, and had a capacity of 18.51 cu. ft. In the table of sizes of sand and stone gages, given on page 219, the "volume in cu. ft." is the theoretical amount required for the specific mixture of concrete. As the men who made these gages were not master carpenters, as few and simple dimensions as possible were given them to work from, and the contents of the gages vary a few hundredths of a cubic foot from the theoretical quantity. The resulting mixture is uniform, however, which it would not be if barrels from which the cement had been taken had been used as gages.

Regarding the second inquiry: The proportions of the Class "A" concrete at the head of Table II. should read 1:2½:4, as stated in the text in the first paragraph under "Concrete Masonry." Very truly yours,

C. M. Saville.

Boston, Mass., March 20, 1902.

The Pecos Valley Rock-Fill and Earth Dam, Near Eddy, N. M.

Sir: In your issue of March 20, you publish a letter from "Western Engineer," calling attention to the fact that in my book on "The Design and Construction of Dams," 4th edition, I show the water on the wrong side of the Pecos Valley Dam No. 2; viz., on the side of the rock-fill instead of on the side of the earth-fill.

On page 125 of my book on dams, I state that most of the information given about rock-fill dams was taken from a very valuable report on "Reservoirs for Irrigation," by Mr. James D. Schuyler, M. Am. Soc. C. E., which was published in Part 4 of the Eighteenth Annual Report of the United States Geological Survey. The diagram in my book showing the Pecos Valley Dam No. 2 is an exact reproduction of the one given by Mr. Schuyler in this report.

The report does not state on which side of the dam the water is. While "Western Engineer" is no doubt right in saying that the impervious earth-filling should be on the water-side of the dam, I have found in my studies of dams more than one case where a dam might have been reversed to advantage from the position in which it was constructed, making the down-stream side the up-stream one. It is quite conceivable that an engineer might construct an earth bank against the down-stream side of a rock-fill dam to stop leakage.

Some time ago a Western engineer, possibly your correspondent, wrote a letter to my publishers, Messrs. John Wiley & Sons, drawing their attention to the fact that one of my diagrams showed the water on the wrong side of a Western dam. Unfortunately, this letter was lost, either in my publisher's office, or in mailing to me, and I did not know, therefore, where I had made an error.

I must thank you for drawing my attention to this matter by publishing the letter from "Western Engineer," and will have my diagram corrected in the next edition of my book. Yours very truly,

E. Wegmann.

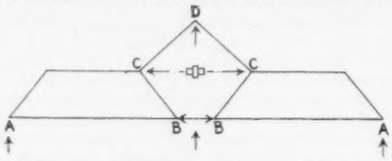
Katonah, N. Y., March 22, 1902.

The Non Continuous Swing Bridge Again.

Sir: Some 23 years ago the writer discussed with other engineers the various general methods by which swing bridges could be made non-continuous, viz: (1) by the toggle point C D C, (2) by the pulling bars C C, (3) by spreading B B,, (4) by lifting whole span under B B, (5) by lifting the ends A A.

The first method can be operated by screws, wedges or preferably rams; the second can be operated by a right and left screw with a worm, pinion or other device; the third by hydraulic rams; the fourth by rams, as at Raritan Bay; the fifth by rams, toggles or wedges. The late C. Shaler Smith prepared a plan, and I think built it, on the first method, and I am under the impression that the fifth was employed at the Westport bridge on the New York & New Haven R. R. The Raritan bridge was discontinuous when closed and I believe worked very satisfactorily.

After a careful study of these various methods both from the points of view of the mechanical details and the



required time and power to operate, I concluded that for bridges of any magnitude the fourth and fifth methods only were satisfactory.

If Mr. Worthington succeeds in making his plan work satisfactorily he will deserve great credit, but I think he does not give his own design as severe a criticism as he would undoubtedly do in other cases.

The friction on his screws, hinge joints and toggle-bars will be very heavy. His estimate of 20% friction requires lubricated joints with low pressures. As he quotes Unwin, allow me to also quote him:

"There are cases in which pressures, even of a ton or more per sq. in., are carried by lubricated journals without danger of seizing. In most of the cases where excessive pressures are carried, it appears that the pressure is intermittent or reverses in direction so as to come alternately on the two brasses. In such cases it is conceivable that the oil finds a way in during the relief of pressure and is not squeezed out in the short period in which the pressure acts."

Also, in the same table, where Mr. Worthington gets his 3,000 lbs. on "crank pins of shearing machines," he will find that the highest pressure given for the reciprocating joint is "crank head neck journals, 1,200 lbs."

I have no other interest in this matter than a professional one, and having pointed out that part of the problem where the real design comes in, I will drop the subject. Old Fogy.

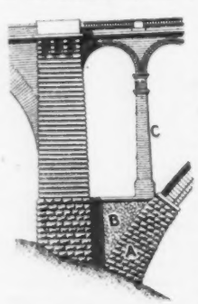
New York, March 14, 1902.

(The diagram which should have accompanied this letter was omitted in printing it last week; it is therefore reprinted.—Ed.)

Another Reflection on the Luxemburg Bridge.

Sir: While examining the Luxemburg Bridge plans, shown in your issue of Feb. 27, I was impressed by certain details of design which appear to me to be very far from pleasing to the eye, and incidentally from inspiring confidence, as to the safety of the design, in the mind of any careful observer other than an engineer. As briefly as possible I will describe the impression conveyed by said details, at the same time risking a guess that they must have been noticed by other readers of your journal.

The details in question are the abutments. Referring to the enclosed sketch, it will be noted that the portion



A has the appearance of a stone column that is bending under the combined weight of the wall B, and the long column C with its load of superstructure. The height of the column C assists the illusion considerably, and the most vivid impression conveyed to the mind at the first glance is that the column A will come crashing down any second under its load.

This criticism is made from a layman's viewpoint, and is merely a matter of taste in design. In all engineering structures, such as this and other large masonry arches, every effort should be made to secure a happy combination of both strength and beauty in the design. Engineers should bear in mind that the only standard by which the layman measures any engineering structure is that "it looks right."

Your suggestion in regard to the design of the abutments, as shown in Fig. 2 of your editorial comment on this bridge, is certainly very pleasing to the eye, and has the appearance of greater strength than the actual design. In fact, the whole editorial is an able treatment of the subject at issue. It is to be regretted that such a noble monument to engineering ability and boldness as is the Luxemburg Bridge should be marred by a lack of taste in the designing of an important detail. Yours truly,

H. F. Wilson, Jr.

Birmingham, Ala., March 11, 1902.

Some Reasons for Building the Luxemburg Bridge of Stone Masonry.

Sir: Having been a reader of your valuable paper since my arrival in this country about 18 months ago, and being also a native of Luxemburg, I was much interested in the description and criticism of the Luxemburg Arch which appeared in your issues of Feb. 27 and March 6.

It may be of interest to your readers to know the reasons which influenced the engineers of in adopting stone masonry. At the outset it that since Luxemburg is one of the great centers of Europe, there was a strong party a metal structure. Nevertheless, a masonry finally adopted.

The city of Luxemburg possesses a numb viaducts, all built of stone during the 19th century. It seemed more in keeping, build the new bridge of masonry, and it was great arch span shows the advance made in constructing masonry bridges in a striking compared with the neighboring viaducts of struction. Luxemburg has excellent stone quar tered over the country, the products of which Germany, Belgium, Holland and France. The is a splendid advertisement for these quarri of its location, Luxemburg is a famous tourist these tourists the bridge is a new attraction, engineering work fitting admirably in its surro

I do not think that the cost of the stone ar much greater than the cost of a steel arch, b greater part of the stone required—about 15,000 is found almost on the spot. For the steel ma and erector the bridge would be a comparative job, but for the stonemasons it is a very l Moreover, if the bridge were built out of steel, pany would have received all the money, and holders of the large steel companies are mostly residing abroad, while the miners are mostly Walloons, etc., and thus are foreigners also. industry, however, is represented by the "plain the country," and, therefore, the representatives people, the Chamber of Deputies, preferred the tion which most benefited their constituents. It is this last reason is largely a sentimental one, but it influences the people, and the bridge is built with money.

Another reason which perhaps had considerable influence in the selection of a masonry bridge was the following: The border of Luxemburg and Germany is formed by three rivers, the Moselle, the Saar and the Oise. Over these streams different Luxemburg cities and communities have built bridges, some of iron and some of stone. All those who have built steel bridges regret it because of the continuous cost of repairs and inspection. On the other hand, once a stone bridge has been built it was built and done, and the community could direct its attention to other improvements. Yours truly,

John N. Bellwald

Trenton Iron Co., Trenton, N. J., March 9, 1902.

Concerning Railway Location and Construction.

Sir: I took great pleasure in reading Mr. Barr's letter in your issue of March 6. There seems to be very little literature to help the locating engineer in his work, as compared with other lines of engineering. So far as my little experience has gone, good locating engineers are very few—and they are born rather than made. A good locating engineer must have an "eye for country." Having been given a maximum for grade and curvature, all the college training seems to be forgotten in looking for "saddles" and good ground to lay on. An engineer should never be handicapped by having to make this or that place, regardless of a good line between terminii. The main object after the road is completed is to pull a full train over the whole division without having to double hills and back up to make a run for a bad place in the line. If you can't get to "Brown's Sawmill" or a small town, let them come to you. If your line is ever going to amount to anything you must so locate it that no one can parallel you a few miles away in after years with better grades and alinement.

Operating a railway is like running a mercantile business. You certainly cannot continue in business if the original cost, and possibly I might say your capital is unduly swelled by excessive cost for materials furnished by the construction and supply companies. All these expenditures become a fixed charge, which in after years the company must pay interest on before a profit can be realized. The firm which can do business on the smallest margin and still pay a profit on the investment will surely prosper.

The greatest handicap that a new railway can have is a set of officers who are connected with supply and construction companies, making everything used in the construction of the line cost more than if purchased from first hands. A good superintendent, who will surround himself with men who will work together without friction and without dishonesty, is also a most important point in a railway's success. Yours truly,

Geo. H. Cooke.

Assistant Engineer, Southern Indiana Ry. Co.

Bedford, Ind., March 10,1902.

(In the art of railway location there are exceptions to every rule. What our correspondent says applies to railways which are to haul enough freight traffic to load a locomotive up to its haul

ng capacity. At least half the railway mileage of the United States, however, will never have more than a light local traffic. Here a limit is soon reached beyond which it will not pay to spend money to reduce grades and curves.—Ed.)

Railway Location; Good and Bad.

Sir: Referring to the article, "Concerning Railway Location," by P. F. Barr in your issue of March 6, 1902, the writer regrets that Mr. Hardesty in the same issue did not, in his account of the Union Pacific revisions of location, give a statement of comparative values of the old and the new lines. But the question of the wisdom of the "Leroy-Bear River Cut-off" is commended to Mr. Barr. From the data given we may make a fairly approximate guess of costs as follows:

Revised line:	
Earth borrow, 728,000 yds. at 15 cts.....	$109,200
Earth excavation & haul, 632,000 yds. at 20c.	126,400
Rock excavation & haul, 541,000 yds. at 70 cts.	378,700
Tunnel " 120,000 yds. at $4.....	480,000
Shaft " 1,800 yds. at $8.....	14,400
Tunnel timbering, 4,500 M. B. M., $35.....	157,500
" steel, 1,450,000 lbs., 4 cts.....	58,000
" concrete, 6,240 yds. at $10.....	62,400
Permanent lining to be done, 5,200 ft.....	551,200
Taking up and relaying track, 53 miles at $500.	26,500
	$1,964,300
Add 5%.....	98,215
	$2,062,515

The 5,200 ft. of concrete and steel lining yet to be done is assumed to be 2 ft. thick with steel ribs 3 ft. c. to c.

Original line:	
Excess capitalized cost of operation as follows:	
Excess length, 50,000 ft. at $6.....	$300,000
" rise and fall, 280 ft. at $600.....	168,000
" curvature, 1,570° at $75.....	117,750
Asst. engines for heavier grade.....	600,000
	$1,185,750

This leaves a balance of $876,765 in favor of the old line. As a choice between two lines originally and before either was built, we can add $620,000 for cost of 31 miles of the old line and still have $256,765 in favor of the latter.

It must also be kept in mind that the considerations now entering the question of justifiable expenditure to reduce cost of operation were by no means all pertinent when the line was first located, in addition to which the 9.5 miles excess length carried a bonus.

The estimate above assumes 20 trains daily one way, two assistant engines running 150 miles per 24 hours and money at 5%.

Now as to the cost of the tunnel. Evidently, it is far in excess of the estimate made for it when the adoption of the new location was decided. If we are going to hold the locating engineer strictly accountable for the full discovery and proper solution of all the economic problems involved in his location, it is evident that here an error was made in not fully determining in advance the nature and condition of the material to be tunnelled, or, if that was done, the estimate of the difficulties of controlling it was entirely too low. The writer is not censuring anyone responsible for this work. Doubtless there are reasons and conditions not apparent to him for the things that have been done.

Neither is a tunnel a thing always to be avoided, even in questions of first cost. Sometimes an engineer makes a mistake in adhering to a determination to avoid all tunnelling on his location.

Last year the writer revised 42 miles of a line that had been twice located through a very heavy section of the Ozark Mountains of Missouri, on the theory of high-grade lines to go through the principal divides (of which there are three) in open cuts. As a result, the line was hung up on the points of a very abrupt and broken country, giving excessive cuts and fills, involving some 4,250,000 cu. yds. of pay quantities in 42 miles, the residual of which is now costing on construction an average of about 50 cts. per yd.

The writer dropped the grade lines, taking three tunnels, 700, 1,200 and 1,700 ft. long, respectively. By so doing, the alinement was improved and curvature, rise and fall and length of maximum grades were all reduced. The quantities were reduced 2,250,000 yds., representing a saving on present cost of construction of $1,125,000 for graduation and $135,000 on rise and fall and curvature. Against this is to be charged cost of 3,600 ft. of tunnel at $216,000 and 3,000 ft. excess length of line at $30,000, leaving a balance of approximately $1,000,000 in favor of the tunnels.

Drilling during location indicated that all the tunnel work would be in good and almost dry solid rock. The work to date confirms this and the estimates of cost.

Therefore, when a locating engineer is "Burning the midnight oil" in a solution of a knotty point to avoid a tunnel, he may be saving money or he may not be.

The writer knows that there is plenty of bad location. Still, if all of the possible better lines were put on the right side and all of the possible worse lines on the left of the average railway location, the possible bad lines never located would be in a vast majority over the possible good lines never discovered.

Considering the endless possibilities for error in this work, it is to the credit of the locating engineer that he keeps as close as he does to the best. Yours very truly,

J. L. Campbell.

915 Security Building, St. Louis, Mo., March 10, 1902.

A Criticism of the Methods Employed in Letting Naval Contracts.

Sir: The writer having perused a number of specifications written to govern contract work done under the supervision of the Navy Department, as well as having supervised such work, desires to complain against the injustice in the methods adopted in letting contract work to irresponsible contractors.

One of the standard clauses in the Navy Department specifications reads as follows:

Before he is awarded the contract any bidder may be required to show that he has the necessary facilities, experience and ability to perform the work in a satisfactory manner.

Yet, every day large and important contracts are awarded to (so-called) contracting firms who have never successfully entered upon or executed a contract, whose only plant is carried in their hat or else located in a ten by twelve office on the tenth story of some skyscraper, from which they peddle forth their subcontracts to the lowest bidders, without making any effort to satisfy themselves in regard to the ability or responsibility of such subcontractors to properly execute their contracts. Such subcontractors, in order to secure the work, bid a price which is generally far below a fair market value, relying on performing their contracts on the strength of their ability to discover a loophole by which they can evade the specifications, or, if not successful in that, on abandoning the contract when they have gotten out of it all that is profitable.

Responsible contractors immediately ask the whys and wherefores of all this. The question is readily answered by those that are conversant with the facts: The lucky or unlucky individual, whichever you may see fit to term him, who has been awarded the contract, figures, first, that he can hire alien labor at a dollar a day; second, that the government will furnish him with the necessary plant with which to execute his contract. For those who may doubt the latter statement, the writer will say that he has seen a contractor, who had a fair-sized contract, enter a navy yard and attempt to begin operations with the only tool which he had in his possession, a 15-ft. ladder. This individual actually performed his contract by securing the necessary tools either by begging, borrowing, or, if necessary, stealing them.

Now that the subject of appropriations for public works is before Congress, would it not be an opportune time to introduce legislation prohibiting contractors employed on public works on government reservations from employing alien labor, and also compelling the payment of at least the minimum wages paid for corresponding work by private individuals on the outside. The writer believes it would also be a good thing if Congress would pass a law which in the main should read as follows:

That before any person, persons or corporations shall be permitted to submit proposals or contract for any work where the public funds are to be expended, they shall cause to be filed with the officer or agent having the work in charge, a certificate showing their qualification to perform such work, such certificate being signed and certified to by the chief of the bureau having the work in charge.

If I am not mistaken, practically what is equivalent to the above is in vogue on some of our leading railways. As I have always understood it, the New York Central R. R. has maintained a list of contractors who have successfully and satisfactorily performed work on its lines. From such and from such only are proposals invited.

Very truly yours, S. J. F.

New York, Feb. 28, 1902.

(According to the first paragraph in our correspondent's letter, the officers of the Navy Department already have the authority to reject proposals from irresponsible contractors. We do not see that additional legislation by Congress would help matters. Our own understanding of the matter is that the formalities required by law or by custom for the submission of bids to the Navy Department have involved so much red tape that on certain classes of contracts where the amounts involved are not large, bona fide dealers refused to take the trouble to submit bids. There grew up, therefore, about the navy yards a class of professional contractors, who were simply middlemen between the Government and the party actually performing the contract. These middlemen, as our correspondent says, had no capital, plant, or stock in trade except their knowledge of the Government red tape; but by combinations among themselves they were frequently able to make large profits. Two or three years ago, we believe, an attempt was made to eliminate the red tape from naval work, so that bona-fide dealers and contractors would come in and bid direct for work to be done or supplies to be furnished. Our correspondent's letter, however, would indicate that full success has not yet been attained.—Ed.)

(A proof of the foregoing editorial comment was submitted to the writer of the letter above, who sends in reply the following additional letter. Ed.)

Sir: There is not so much red tape in securing a contract under the Navy Department as is commonly supposed. The specifications as written for navy yard work are not nearly so rigid or specific as are those written to govern similar contracts for railway companies and private corporations. The writer believes that if the Navy Department specifications and plans were more rigid and specific the government would secure cheaper and better work and give fewer opportunities to contractors for evasion and delay. Regarding the specifications, the clause stating "that all work and material must be satisfactory to the civil engineer in charge," confronts the contractor in nearly every paragraph, leaving him in doubt as to the requirements and at the same time affording him a chance to substitute inferior work. Your comments in regard to middlemen are well made, and the writer believes that if the government specifications were written with the idea of furnishing complete and specific instructions and leaving nothing in doubt, in regard to the nature of the work to be performed, that government contract work would be far superior to what it now is.

S. J. F.

New York, March 24, 1902.

The Economical Application of Transition Curves to Old Track.

Sir: The subject of transition curves, and their application to railway curves, has been quite thoroughly discussed during the past few months in the technical press, and particularly in the Proceedings of the American Society of Civil Engineers, in connection with the paper on this subject presented by Mr. W. B. Lee, but I fail to find the question of economy of application brought forth as an argument in favor of any of the forms presented.

The writer having had occasion lately to look into the merits of the different forms of transition curves in use, for a report on the subject, has been much interested in the published discussion thereon. Upon comparison, it is found that for the same length of curve, there is little variation in the offset distance, given by the different tables published, which consist either of a series of compound curves, or of an arc of a cubic parabola, or an approximation of the latter. The only advantage possessed by one over the other is in the manner of application and the tabulation of the calculations. It is conceded that the cubic parabola is the ideal transition curve, the reason given for the use of the other curves being their supposed simpler form. The length of curve to use is, then, the point that requires attention, and this should increase with the speed of the train and the degree of the curve to which it is applied. These being the same factors that regulate the elevation of the outer rail of the curve, it follows that a formula for the length of the transition curve should have for one of its factors the formula for the elevation of the outer rail. These requirements have been fulfilled in a formula presented by Mr. C. A. Sundstrom, in the October Proceedings of the American Society of Civil Engineers, together with some very simple formulas based on the equation for the cubic parabola for calculating the offsets and deflections to points on the curve.

It is generally conceded that no fixed rule can be given for the elevation of the outer rail of curves, and that each curve has its own peculiarities and must be dealt with individually, not because the formula for elevation of the outer rail in proportion to the speed is faulty, but because on hardly two consecutive curves does the train have the same speed, the grades producing the variation. An example of the extremes of this variation is the location of a curve at the foot of a heavy grade, where trains are either "making a run" to get up the grade, or have their speed accelerated by momentum acquired in coming down the grade, and another curve of same radius located at or near the summit, where trains are always moving at a comparatively slow rate of speed.

The result of this variation in the elevation required has been that the matter of the amount of elevation to be put on a curve is left to the judgment of the road-master and his immediate superior, the requirement being that the curve shall "ride well" under the traffic to which it is subjected, the only limitation being that the extreme elevation shall not exceed a certain amount, usually 6 ins. With the elevation decided as above, which is the common practice, the way to apply a transition curve of the proper length, to agree with the speed for which the curve is elevated, is to measure the elevation in the track, and use the speed corresponding thereto, in calculating the length of the transition curve to be used. While this could easily be done in the field, it is better, to save time and chances of error, to have tables computed from which the data can be taken direct.

The above method of determining the length of case-

ment curves is original so far as the writer knows, and no tables having come to his notice that were properly constructed for application in the manner mentioned, he has compiled a set, one of which is given below.

These tables have been calculated for speeds of 30, 35, 40, 42.5, 45, 50, 55 and 60 miles per hour, and by taking from the tables, the curve of proper degree, that comes nearest to having the elevation found in the track, the transition curve is readily staked, either by offsets or by deflection angles. In these tables the length of the easement is 300 times the elevation of the outer rail, which makes the length for a curve that is elevated 6 ins. 150 ft., which gives an easy grade on the elevated rail.

One of the advantages of this method of determining the length of the easement is that it is not dependent on the judgment or experience of the person staking same. It often happens that assistants who are perfectly capable of doing the field work, connected with staking curves, are lacking in experience, and are therefore not competent to decide what length of curve to apply to nearest meet the requirements of any particular case, but by this method they secure the data from which to decide from the track to be staked and are therefore perfectly able to do the work as well as some more experienced engineer.

There is no class of maintenance work where it is as easy to waste money as in setting track centers, and particularly in restaking the center line of curves, and anything that tends to reduce this waste is worth considering.

Easement Curves for Speed of 42.5 Miles Per Hour.

Degree of curve.	L	Elevation outer rail on center curve.	Values for x = ¼ L.	Y.	Deflection angles. x = ¼ L.	x = ½ L.	x = ¾ L.	x = L.	Tang. angle at x = L = P.C.C.	Chord dist. for L
	2	O								2.
2	29.8	0.05	0.20	14.9	0.003	0° 1′	0° 3′	0° 7′	0° 12′	0° 24′	29.8
2—30	37.3	0.10	0.25	18.7	0.01	0° 1′	0° 5′	0° 11′	0° 19′	0° 38′	37.3
3	44.7	0.17	0.30	22.4	0.01	0° 2′	0° 7′	0° 15′	0° 27′	0° 54′	44.7
3—30	52.2	0.28	0.35	26.1	0.02	0° 2′	0° 9′	0° 21′	0° 36′	1° 12′	52.2
4	59.8	0.42	0.40	29.9	0.03	0° 3′	0° 12′	0° 27′	0° 48′	1° 36′	59.8
4—30	67.0	0.59	0.45	33.5	0.04	0° 4′	0° 15′	0° 34′	1° 0′	2° 0′	67.0
5	75.7	0.87	0.50	37.9	0.05	0° 5′	0° 19′	0° 42′	1° 13′	2° 26′	75.7
5—30	81.9	1.07	0.55	41.0	0.07	0° 6′	0° 22′	0° 51′	1° 30′	3° 0′	81.9
6	89.3	1.39	0.60	44.7	0.09	0° 7′	0° 27′	1° 0′	1° 47′	3° 44′	89.3
6—30	96.8	1.63	0.65	48.4	0.11	0° 8′	0° 31′	1° 11′	2° 6′	4° 12′	96.8
7	104.2	2.21	0.70	52.1	0.14	0° 9′	0° 36′	1° 22′	2° 25′	4° 50′	...
7—30	111.7	2.91	0.74	55.9	0.17	0° 10′	0° 42′	1° 34′	2° 47′	5° 34′	...
8	119.1	3.29	0.79	59.6	0.21	0° 12′	0° 48′	1° 47′	3° 10′	6° 20′	...
8—30	126.5	3.71	0.84	63.3	0.25	0° 13′	0° 54′	2° 1′	3° 35′	7° 10′	...
9	133.9	4.68	0 89	67 0	0.29	0° 15′	1° 0′	2° 15′	4° 0′	8° 0′	...
9—30	141.3	5.50	0.94	70.7	0.34	0° 17′	1° 7′	2° 30′	4° 35′	9° 10′	...
10	148.8	6.57	0.99	74.4	0.40	0° 19′	1° 14′	2° 47′	4° 56′	9° 52′	...
1	2	3	4	5	6	7	8	9	10	11	12

An easement curve that is longer than it should be for the elevation given the track means a greater offset distance than is of any benefit, which in turn means unnecessary lining over of track and waste of money. A 5° 30′ curve with 6-in. elevation is elevated for a speed of a little over 40 miles per hour, and would have 150 ft. of easement; at just 40 miles per hour the length of easement from tables is 146.2 ft., and the offset distance is 0.86 ft. To give this curve 225 ft. of easement, which corresponds to about 50 miles per hour, the offset distance would be 2.10 ft., 1.24 ft. of which would be useless as far as improving the riding of the curve is concerned, while to give it an easement of 80 ft., corresponding to a speed of 30 miles per hour, with an offset of 0.27 ft., would be disturbing the track for but small benefit.

The speed of trains should be reduced as the curvature is increased so that the elevation for the speed run shall not exceed the limit allowed on the road; this should be the case both as a matter of safety and for the smooth riding of the trains. With a limit of 6 ins. of elevation for the outer rail, the limit of the speed of trains around curves should be as follows:

		Miles per hour.			Miles per hour.
10°	curve.....	30	4° 30′	curve.....	45
7° 30′	"	35	3° 30′	"	50
5° 30′	"	40	3°	"	55
5°	"	42.5	2°,30′	"	60

With the speed regulated as above and easement put on as recommended smooth-riding curves will be secured. A 10° curve on which the main curve is set in 1.62 ft. is the maximum for which the writer has made his tables (the 1.62 ft. being on a curve with elevation of 6 ins.), and this offset distance, and any others that are 6 ins. or over, should be divided so that half of the curve will be thrown out one-half the offset distance, and the other half thrown in the balance, which will reduce the maximum throw of track to about 10 ins. This can be done by taking the external secant of the curve as found on the ground and deducting 1½ times the offset distance to be used, and changing the degree of the curve to correspond to this corrected distance; this will sharpen the curve a little, but it will not exceed four or five minutes, which will not be appreciable, and greatly reduces the expense of lining over the curve. By the use of the methods described the expense of introducing transition curves on old track is reduced to a minimum and the necessity for widening embankments or cuts entirely avoided, and in these days of economical management of railways this saving in the cost of track work is an important item.

C. A. Morse, M. Am. Soc. C. E.

La Junta, Colo., Feb. 4, 1902.

Notes and Queries.

In the article by Mr. W. B. Patton on the Duluth Ferry Bridge in our last issue, a column formula on page 228 was presented by the printer in unintelligible form. Correctly printed it should read as follows:

For soft steel:

$$P = 15{,}000 \div \left[1 + \frac{l^2}{13{,}500\ r^2}\right]$$

For medium steel:

$$P = 17{,}000 \div \left[1 + \frac{l^2}{11{,}000\ r^2}\right]$$

Mr. P. F. Barr, whose letter entitled: "Concerning Railway Location" was published in our issue of March 6, informs us that the letter as printed does not meet with his approval by reason of editorial changes made in the text in preparing it for publication. Through an oversight, a proof of the letter with the changes referred to incorporated was not submitted to its writer before publication, as is our usual custom.

A BRICK ARCH OF 4200 B.C. is described in a recent lecture by Prof. W. M. Flinders Petrie, D.C.L. This barrel-vaulted passage was found—in 1901—in the tomb of King Neter-Khet, in upper Egypt, and belongs to the beginning of the Third Dynasty, or about 4200 B.C. The oldest brick arching previously known was the magnificent work of the Sixth Dynasty, about 3400 B.C., which shows a long familiarity and free use of this brick work. A peculiarity of the older and cruder brick masonry was the generally adopted external batter of the walls, a feature continued in later Egyptian stone masonry until it became a great source of weakness. The inclined walls of the pylons at Karnak, and other points, were backed with mere chips of stone.

THE RESERVATION OF THE PINES BELT of Southern New Jersey is reported upon by Mr. John C. Smock, in Forestry Bulletin No. 1, issued by the Geological Survey of the state. In 1894 the Legislature authorized the Survey to examine the forested lands of the state and ascertain what portions were suitable for reservation. The region known as the Pines Belt lies in the coastal plain zone of the state and covers nearly 2,000 sq. miles. The soil is sandy and unsuited to agriculture, and the timber on it is mainly pitch pine and the short-leaf yellow pine, with much oak coppice, and white cedar bordering the swamps. The report says that individual effort to care for this woodland is ineffectual; and the low price of the land would make acquisition by the state possible. It could be made to yield an income under proper state management; but the greatest advantage of such ownership would be the control and conservation of the water supply upon which so many seaboard and Delaware River towns depend. Mr. Vermeule, in his report of 1898, estimates that south of Tom's River the streams flowing out of the Pines Belt would yield 168,600,000 gallons daily, without storage; or 615,700,000 gallons with storage.

A PEAT BRIQUETTE PROCESS has been developed in Germany by G. Heine, and is being exploited by Mr. Hugo Krupp, of Hanover, Germany. A large part of the expense of most peat handling processes is the labor involved in cutting the peat from the bog and transporting it to the factory for treatment. In the Heine process a portable centrifugal pump dredger is used to excavate the peat from the bog, rotary cutters being used on the suction pipe so that the peat is reduced to a pulp. This pulp with about 15 times its volume of water is carried by a pipe line to the briquetting factory. The pump suction is so protected that stones and roots cannot enter, and sand and clay fall to the bottom of the bog. At the factory the peat pulp is delivered into a vat, from which it passes to a centrifugal separator, which extracts the bulk of the water. The peat then passes to a cylinder press, which operates on a principle similar to that of a paper-making machine. Here the peat becomes a thin sheet, which is carried by belt conveyors to drying cylinders. These reduce the moisture to 15 to 30%, an amount sufficient for briquetting. The peat, now a hot [illegible] is automatically fed to the briquetting machine [illegible] submitted to a pressure of about 2,000 atmospheres [illegible] bituminous parts of the peat act as a cement, [illegible] product is a hard, coal-like, clean briquette. [illegible] of these briquettes show, in percentage—Carbon [illegible] hydrogen, 4.8; oxygen, 22.1; ash, 9.0; water, 11.0 [illegible] corresponds in heating value to 4,850 calories per [illegible] gram, as compared with 5,500 calories for ordinary [illegible] and 3,000 for wood. By carbonizing the peat to a [illegible] degree the heating value may be increased. One [illegible] ton of these briquettes in Germany is said to cost [illegible] $1.20 to $1.68 to produce, according to the size [illegible] plant. A plant for producing 50 tons per day is [illegible] cost $80,000.

THE PROPOSED INDO-CHINA RAILWAY [illegible] scribed in the "Board of Trade Journal" of London. [illegible] 1-meter gage road would connect Haiphong with [illegible] nan-fu, and owing to the disfavor with which it is [illegible] by financiers, the Tonkin government has conceded [illegible] liberal terms to the French company now being [illegible] for construction. The line lies in the extreme north [illegible] French Indo-China, and would pass through Lao-kai.

GERMAN-AMERICAN COMMERCE is discussed by [illegible] U. S. Bureau of Statistics. The United Kingdom alone [illegible] exceeds the United States in its commercial relations [illegible] Germany. Our commerce with that country has grown [illegible] from less than 30 millions in 1865 to nearly $300,000,000 [illegible] in 1901. In 1865 the imports into the United States from Germany amounted to $9,563,743, and the exports to Germany amounted to $20,315,102; in 1901 these figures were $100,445,902 and $191,780,427 respectively. From Germany we chiefly receive finished manufactures, and we chiefly send them foodstuffs and manufacturing materials. In 1901, however, we sent them $5,978,720 in iron and steel manufactures, and received from them of the same class $2,811,006.

THE DECREASE IN THE EXPORTATION of manufactures of iron and steel, in this year as compared with the last, is explained by the U. S. Bureau of Statistics as being due to prosperity at home and to depression abroad. The iron and steel exports, for the seven months ending with January, 1902, amounted to $57,310,128, as compared with $73,616,467 for the corresponding period ending January, 1901. There was also a falling off in the corn export, for the eight months ending with February, 1902, from $60,621,569 for the same period ending in 1901, to $13,683,200. This loss of $46,938,369 is due to the shortage in our corn crop as the result of the drouth of last summer. As to the manufacture of iron and steel, the depression in the home markets in 1893-97, combined with a large demand from abroad, caused a phenomenal growth in exports. But the conditions are now practically reversed. The demand from abroad has been considerably decreased, and that of the home market is absolutely in excess of the producing capacity of the iron manufacturers, and of the railways to handle the products demanded.

A VERTICAL-SIGHTING COMPASS has recently been invented by Mr. J. S. J. Lallie, of Denver, Colo. The instrument is provided with a graduated circle, with double vernier, reading all horizontal and vertical angles to single minutes. The tripod-head is so arranged that all angles of elevation or depression can be taken, independent of the needle. It is thus admirably adapted to clinometer work; to the extension of transit lines up or down hill; to trace mineral veins, etc. A variation plate is provided to set off variations of the needle. The instrument is made of hardened aluminum, and the whole outfit, in a sole-leather sling case, weighs only 4 lbs.

THE COAL FIELDS OF THE UNITED STATES, according to the annual report of the U. S. Geological Survey for 1900-01, now in press, cover a total area of about 280,397 sq. miles, exclusive of Alaska, and also vast areas of lignite. Of this total about 55% is probably productive. The Appalachian coal field, extending from Northern Pennsylvania to Central Alabama, contains about 70,800 sq. miles; of which about 75% contains workable coal. The Northern Interior field, of 11,000 sq. miles, lies wholly within Michigan; the Eastern Interior field, lying in Indiana, Illinois and Kentucky, contains 58,000 sq. miles, with about 55% of this productive; the Western Interior and Southwestern fields are practically continuous from Northern Iowa to Central Texas, 880 miles; they cover 94,000 sq. miles. The Rocky Mountain fields extend from the Canadian border southeastward for 1,200 miles, with a maximum width of 500 miles; they aggregate 43,610 sq. miles. The San Carlos field, of El Paso county, Texas, and that of Uvalde county, Texas, properly belong to the last-named field. The Pacific Coast fields cover 1,000 sq. miles, with the most important deposits in Washington. The lignite deposits, not included in the above summary, cover about 55,000 sq. miles in Montana, the Dakotas and Wyoming; a similar belt runs across the Southern States from Georgia to Texas. Alaskan coal fields are also discussed in this paper, and promise good results.

BOOK REVIEWS.

CENTRAL STATION ELECTRICITY SUPPLY.—By Albert Gay, M. Inst. E. E., and C. H. Yeaman, A. Inst. E. E. London: Whittaker & Co. New York: The MacMillan Co. Cloth; 5½ × 7½ ins.; pp. 467, with 200 illustrations. $3.

This book is written by two English electrical engineers and relates entirely to English central station practice, which differs so widely from current practice in the United States at the present day that the book can seldom be of direct service as a practical guide to the American engineer. On the other hand it is of considerable interest to study the lines on which central station development has taken place abroad, and as the book before us is well written and covers the entire field of central station design, it should find many readers here.

LIGHT, HEAT AND POWER IN BUILDINGS.—By Alton D. Adams, M. Am. Inst. Elec. E. New York: Wm. T. Comstock. Cloth; 5 × 7¼ ins.; pp. 102. Price, $1.

The author in his preface says that his object has been "to present in compact form the main facts on which the selection of the sources for light, heat and power should be based." We do not see, however, that the party charged with the responsibility of deciding the question of isolated plant vs. public supply or the selection of a heating system, for example, will be materially assisted by this book. If the selection is to be made by a competent engineer, the book will tell him nothing he did not know before, and if the owner or architect seeks the book for guidance the chances are he will stumble over some of the computations in the book and he will be quite as likely to come out right if he goes ahead with only the assistance of plain common sense.

POWER AND POWER TRANSMISSION.—By E. W. Kerr, M. E., Assistant Professor of Mechanical Engineering, Agricultural and Mechanical College of Texas. First edition. First thousand. New York: John Wiley & Sons. Cloth; 6 × 9 ins.; pp. 356, with 264 illustrations. $2.

The principal use of this book, we judge, will be as a text-book in trade schools, agricultural colleges and similar institutions where the time devoted to the subjects which it covers is too limited to permit more than an elementary treatment. The book is divided into three parts, as follows: I. Machinery and Mechanics. II. Steam Power. III. Pump, Gas Engines, Water Power, Compressed Air, etc.

The mere fact that such a wide range of subjects is covered within the limits of about 340 pages, a large portion of which are taken up by illustrations, will sufficiently indicate how brief space is devoted to the separate subjects.

Notwithstanding its brevity, the work appears to be well done on the whole, and the author seems to have exercised good judgment in deciding what points to include and what to omit in his very brief discussion. The treatment is so simple, as a rule, that the book will be found suitable for self-instruction.

THE JOURNAL OF THE IRON AND STEEL INSTITUTE, No. II., 1901. Vol. LX. Edited by Bennett H. Brough, Secretary. New York: Spon & Chamberlain, 12 Cortlandt St. London: E. & F. N. Spon, 125 Strand. Cloth; 5½ × 8¼ ins.; pp. 595; illustrated.

The Autumn Meeting of the Iron and Steel Institute was held at Glasgow on Sept. 3-4, 1901, with President William Whitwell in the chair. The present volume is devoted to the proceedings at that meeting, to the publication of the papers presented at that time, and to notes on the progress of home and foreign iron and steel industries. Papers were read, as follows: Presidential Address; Iron and Steel Industries of the West of Scotland, H. Bumby; Variations of Carbon and Phosphorus in Steel Billets, A. Wahlberg; The Correct Treatment of Steel, C. H. Risdale; Alloys of Copper and Iron, J. E. Stead; Effect of Copper on Steel for Wire Making, J. E. Stead and F. H. Wigham; The Presence of Calcium in High-Grade Ferro-Silicon, G. Watson Gray; The Profitable Utilization of Power from Blast-Furnace Gases, B. H. Thwaite; The Spectra of Flames at Different Periods During the Basic Bessemer Blow, W. M. Hartley and H. Ramage; Brinell's Method of Determining Hardness and Other Properties of Iron and Steel, A. Wahlberg; The Internal Strains of Iron and Steel and the Bearing Upon Fracture, A. Wingham; Report on the International Congress for the Unification of Methods of Testing, B. H. Brough.

THE PRINCIPLES, CONSTRUCTION AND APPLICATION OF PUMPING MACHINERY (Steam and Water Pressure), With Practical Illustrations of Engines and Pumps Applied to Mining, Town Water Supply, Drainage of Lands, etc.; also Economy and Efficiency Trials of Pumping Machinery. By Henry Davey, M. Inst. C. E., M. Inst. Mech. E., F. S. S., etc. London: Chas. Griffin & Co. Philadelphia: J. B. Lippincott Co. Cloth; 6½ × 9 ins.; pp. 295, with over 250 illustrations. $6.

This book is chiefly useful to the American engineer as a curiosity. Its title is broader by far than its contents, as will be readily understood when it is said that at least two-thirds of the book is devoted to pumping engines of the Cornish type, a machine to which English engineers appear to cling with remarkable conservatism. There are a few examples of pumping engines of the modern type, indicating that the author has heard of such things; but they seem to have made no particular impression on him as being any particular improvement over the massive old Cornish engine. There is hardly a mention to be found of the ordinary steam pump, but the author goes out of his way to insert a chapter on shaft sinking, another on hydraulic transmission of power in mines and a third on hydraulic rams, hydraulic air compressors, etc. The illustrations occupy as much or more space than the text, and a large proportion of them are of very poor quality. The extent of the author's knowledge regarding recent centrifugal pumping practice may be judged by his remark that such pumps are not generally used for lifts of more than 20 to 30 ft. and that experiments are wanting as to efficiency with higher lifts.

THE RAILWAY TRANSITION SPIRAL.—By Arthur N. Talbot, C. E., M. Am. Soc. C. E., Professor of Municipal and Sanitary Engineering, University of Illinois. Third edition. Revised. New York: The Engineering News Pub. Co. Flexible leather; 4 × 7 ins.; pp. 110. $1.50.

In accordance with our usual rule in the case of our own publications, we confine our review to extracts from the preface as follows:

> The railway transition spiral here presented is a flexible easement curve of general applicability and of comparatively easy analysis. The conceptions and methods used are similar to those of ordinary circular railroad curves. The definition is based upon degree-of-curve, and degree-of-curve, central angle, and deflection angles may be calculated, and the curve may be located by transit and chain or by co-ordinates from tangent and circular curve. The field work is quite similar to that for circular curves. The spiral is easily applied to a variety of field problems and to a wide range of location and old track conditions. In the principal formulas, angles, co-ordinates, offsets, etc., are expressed in terms of the length or distance along the spiral. The use of series in the development of the properties permits an estimate of the error involved in discarding negligible terms. . . . . .
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> The treatment herein given has been quite widely used on the railroads of the United States, and many engineers have commended its simplicity, convenience and flexibility. The methods and principles are readily taken up by instrument men, and the field work has proved little more difficult than that for circular curves. The use of a regular rate of transition per 100 feet of spiral is advantageous, and the tables are in convenient form.
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> The treatment of the railway transition spiral was published in Technograph No. 5, 1890-91, and was published in field-book size in 1890. Careful attention has been given in this revision to illustrative examples and explanations. The tables have been extended and a treatment of the Uniform Chord Length Method and of Street Railway Spirals added.

DIRECTORY TO THE IRON AND STEEL WORKS OF THE UNITED STATES.—Embracing a full list of the blast furnaces, rolling mills, steel works, rail mills, structural mills, plate and sheet mills, steel casting works, tin-plate works, wire-rod mills, cut-nail works, wire-nail works, and forges and bloomaries, with full particulars of equipment, products, ownership, officers, and all recent consolidations, to which is added a complete list of the iron and steel works of Canada. 15th edition, corrected to Dec. 31, 1901. Compiled and published by the American Iron and Steel Association, Philadelphia, Pa. Cloth; 6 × 9 ins.; pp. 428. Price, $10.

This publication has been issued at biennial periods for many years, and the present edition was due in 1900. At that time, however, changes were too rapid and kaleidoscopic to permit the compilation of the work, and its issue has been postponed therefore to the present time. The first part of the book is entitled "Chiefly Consolidations," and is a record of the plants owned or controlled by the United States Steel Corporation and by some 30 or more of the principal companies in the iron and steel industry, the works belonging to each company being grouped separately. In Part II. is a geographical list of the furnaces, rolling mills and iron and steel foundries and forges in connection therewith in every State in which such works exist. As in previous editions, a large amount of information is given as to the capacity, equipment, etc., of every works described. Part II. also contains a geographical list of abandoned, dismantled or long inactive iron and steel works, which may be of little commercial interest, but cannot fail to attract the attention of any one who cares to trace the history of trade movements and changes. It is curious to note in this list that quite a number of the dismantled works are among those owned by the trusts, and also that not a few of them are of quite recent construction. In Part III., the establishments are classified by their products, separate lists being given of the steel foundries, Bessemer works, plate, sheet and skelp mills, wire-rod mills, and so on for a dozen different branches of the steel industry.

A REMARKABLE NEW HIGH-POWER EXPLOSIVE.

A highly interesting series of tests of a new high-power explosive compound was witnessed a few days ago by a small party of engineers and experts on explosives at the estate of Mr. Fred. L. M. Masury, at Sands Point, Long Island. These tests make the new explosive appear a truly remarkable substance, possessing the explosive powers of dynamite in conjunction with an insensibility to all manner of abuse that makes it apparently as harmless as so much sand. The substance has been named "masurite," in honor of the inventor, at whose invitation the party, of which a representative of this paper was a member, assembled to witness the demonstration. The following brief résumé of the results of the most essential of the tests will give an idea of the value of the material.

"Masurite," as it was used in the tests, is a pale-yellow, granular powder, looking not unlike fine sand. It is about a third lighter than dynamite. It is insensible to heat or cold, or to moisture in the air; prolonged contact with water, however, injures it. The heat of an ordinary flame is sufficient to fuse it, but in melting the substance changes its character and loses all explosive properties. Left alone, the "masurite" will not burn, but in contact with burning carbonaceous materials it slowly burns, giving off incombustible fumes.

RESUME OF TESTS.

CONCUSSION.—"Masurite" placed on an anvil or on a stone was struck with a hand hammer and with a sledge, without effect. An iron ram weighing about 60 lbs. was dropped with a fall of 25 ft. on a 10-oz. paper cartridge, filled with "masurite," placed on an iron anvil. The blow compressed some of the powder into coherent cakes, but had no further effect. Twelve-pound tin cans filled with "masurite" were perforated with shots fired at close range from a 30—40 rifle, using both mushroom and steel-jacketed bullets, without effect on the explosive. The same result was obtained when burning brands of charcoal were placed in the powder and the shots fired through the partly burning mass.

HEAT, FIRE AND ELECTRIC SPARK.—Iron bars heated to redness were run through cartridges filled with "masurite" or used to stir the powder in a 10-lb. can; portions of the powder fused and burned, the latter where in contact with the paper of the cartridge. Large quantities of "masurite" were thrown upon a wood fire, also upon a charcoal forge fire blown vigorously. The substance was fused where the heat was sufficient, and burned where in contact with the coal. Smokeless powder as well as high-grade black powder were placed in intimate contact with portions of "masurite" and set off by a fuse. The "masurite" was not affected. Parlor matches were lighted by rubbing on a rasp while covered with "masurite," without effect on the latter. A melting pot was filled with "masurite" and covered with an iron funnel; the pot was then heated on a forge fire until the "masurite" melted and decomposed. The fumes passing off from the funnel could not be lighted, but extinguished the flame of a match. When "masurite" was rubbed between surfaces covered with sand-paper or emery, no effect was produced. Quantities of "masurite" were heaped upon an iron rasp connected with a 110-volt generator, and a wire connected to the other terminal was rubbed over the rasp. The electric sparks did not effect the powder. A copper wire was placed in a heap of "masurite" and a 110-volt current passed through; the wire was fused, but the powder was not affected.

DETONATION.—A 10-oz. cartridge of "masurite" was fitted in the ordinary manner with a "double-strength" electrical exploder, the exploder being placed in one end of the cartridge. The cartridge detonated violently. A similar cartridge was fitted with a similar exploder tied on the outside; the cartridge exploded as before. A cartridge fitted with an exploder was laid horizontally, and another cartridge without exploder was laid so that the ends of the cartridges touched. On setting off the first cartridge both exploded. Seven such cartridges in a row with their ends touching, only one cartridge fitted with a fuse, and placed at one end of the row, were all exploded when the cartridge with exploder was set off. When a cartridge was set off at a distance of 12 ins. from a cartridge without exploder, the latter was merely torn, but did not explode. A cartridge without exploder was suspended 4 ins. above a "double-strength" exploder, and the latter set off. The cartridge was torn, but did not explode. To give some illustration of the comparative behavior of dynamite and "masurite" under concussion, half of a cartridge of 40% dynamite was detonated at a distance of 12 ins. from a cartridge of "masurite," without exploding the latter, but merely breaking the cartridge. On the other hand a "masurite" cartridge when set off at a distance of 12 ins. from a dynamite cartridge caused the latter to detonate. In this test the manner of explosion of the two materials could be noted: the dynamite gave a bright burst of flame when exploding, while in all the explosions of "masurite" no sign of flame appeared. Finally, to show the effect of cold on the "masurite," a cartridge was placed for three hours in a can surrounded by a freezing mixture. When the cartridge was taken out of the can a thermometer in the can showed a temperature of —6° F.; the cartridge was immediately fitted with a fuse and exploded, behaving exactly the same as the other cartridges which had been fired at normal temperature.

A few weeks ago a rough comparative test of "masurite" and 40% dynamite was made on Section V6 of the New York Rapid Transit Subway, Naughton & Co., subcontractors. In the regular

rock-work on this section a blast of each explosive was set off under conditions as closely alike as possible. The two explosives were used bulk for bulk, and the results were almost equal, but slightly in favor of the dynamite. No test was made weight for weight, but it is probable that the "masurite" would have shown up ahead. The new explosive has been in continuous use for some months in a West Virginia coal mine; it may be noted that it was in connection with coal mining that Mr. Masury, in attempting to find a flameless explosive, discovered this compound, which, in addition to being flameless, seems to fulfil every other conceivable condition for safety. In the mine where "masurite" is being used, a blast of the substance was set off in 20 ins. of firedamp, according to a statement of the mine superintendent, without setting off the gas. Dynamite under similar conditions would almost certainly have caused a gas explosion.

As to the cost of the new explosive, it will, of course, depend on a number of conditions; roughly, however, Mr. Masury gives the cost practically the same as that of 40% dynamite.

"Masurite" is being manufactured by a company which has been formed for its exploitation, the Safety Explosive Co., of 50 Broadway, New York. Mr. Masury is president of the company.

COST OF CRUSHING QUARTZITE BY A MUNICIPAL CRUSHING PLANT AT BARABOO, WIS.

By W. G. Kirchoffer.*

The city of Baraboo, Wis., established a municipal crusher plant during the season of 1901, and the following data of the cost of crushing quartzite at this plant may be of interest to engineers.

The plant consists of an Austin No. 3 crusher, a Sullivan "U. C." steam drill, some small bins and the necessary tools. The cost of the same was: Crusher, $898; drill, $218; bins, etc., $108; picks, shovels, drills, etc., $108; total, $1,333.

In figuring up the cost of the rock to be charged to the street I estimated that the crusher would last 10 years, the drill 5 years, the bins 4 years and the tools 2 years, as is apparent from the table.

The crusher was operated 46.8 days and crushed 1,920 cu. yds., an average of 41 cu. yds. per day. Three sizes of stone were made, 2½-in., 1¾ and ¾-in. down to powder. No record was kept of the amount crushed of each size so I can give only the total amount.

I have added to the table some figures showing what the cost of the stone would have been had we purchased the stone at Ableman, eleven miles distant, and shipped it in on the cars, and the saving to the city by the purchase.

Cost of Crushing Quartzite for Macadam at Baraboo, Wis.

Items.	Total cost each item.	Cost per cu. yd.
Stone in the quarry	$76.80	$.0400
Bins, etc., 25% of $108	27.05	.0140
Crusher, 10% of $898	89.84	.0467
Steam drill (20% of $218) + $7	50.65	.0234
Picks, shovels, etc., 50% of $108	53.90	.0281
Dies for crusher	128.00	.0677
Freight paid on supplies	33.72	.0175
Fuel for engine	134.56	.0744
Oil	6.00	.0031
Dynamite	100.77	.0599
Superintendent's horse and liveries	34.00	.0177
Superintendent of crusher	131.50	.0685
Quarrying stone and tending crusher	1,372.85	.7140
Rent of engine, 468 hours	163.93	.0854
Total cost of quarrying and crushing	2,403.57	1.2520
Hauling 1,920 cu. yds. to city	960.00	.5000
Cost of stone delivered on street	3,363.57	1.752
Cost of stone if same had been purchased	3,301.29	
Cost of hauling purchased stone from cars	729.60	
Cost of purchased stone upon street	4,130.89	
Amount saved by owning crusher	767.32	

IMPROVEMENT IN THE QUALITY OF CHILLED CAR WHEELS.†

By C. H. Vannier.‡

Chilled cast-iron car wheels are distinctly an American product. According to the statistics giving the number of cars in service during the year 1901, there are in round numbers 12,000,000 cast-iron car wheels in use under freight and passenger cars in the United States. In addition to this, cast-iron wheels are used almost exclusively under cars running on street and interurban railways. The total tonnage of cast-iron in use in the shape of car wheels now in service approximates 3,500,000 tons, or about one-quarter of the total output of pig iron in the United States in the past year.

The greatest improvements in the manufacture of cast-iron car wheels have been made within the last 15 years. The life of a cast-iron car wheel measured in mileage has been doubled—that is to say, the wheels which are turned out now are guaranteed for six years, while those turned out 15 or 20 years ago were guaranteed for not more than three years. In the same way in the mileage we guarantee wheels to-day for 75,000 miles, while 40,000 miles was considered a high mileage guarantee 15 years ago.

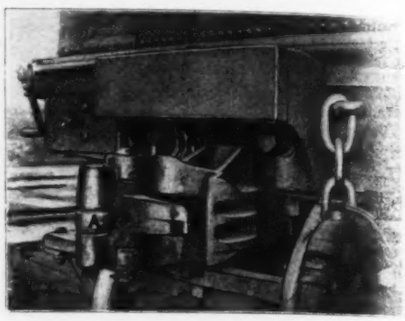
The severe tests required to-day by railroads for cast-iron car wheels could not have been met 15 years ago. At that time five blows was usually specified for the drop test, and there was no such thing as a thermal test. Fifteen years ago the wheelmakers were almost without exception making their mixtures without the aid of chemistry, while to-day chemistry is one of the important factors in the manufacture of car wheels. In addition to this, much has been done in the last ten years in the way of scientific research, and also by taking advantage of physical tests to an extent which would hardly be credited by those not familiar with what is going on. As a result, the quality of the cast-iron wheel has been greatly improved within the last few years, and this was necessary, for the reason that the service required of car wheels at the present day is much more severe than it used to be, owing to the very great increase in the carrying capacity of cars. Twenty years ago a car of 40,000 lbs. carrying capacity was considered something unusual, the ordinary carrying capacity of the cars being 28,000 to 30,000 lbs. To-day a great many cars are being built with carrying capacity of from 80,000 to 100,000 lbs., and the speed of trains has also been very much increased in the past few years, as compared with the practice of 15 or 20 years ago.

The increase in capacity as between the 24,000-lb. capacity cars on the one hand and the 100,000-lb. capacity cars on the other hand amounts to 333⅓%. The increase in the cross-section of the axles at the wheel seat as compared between the axles used under 24,000-lb. capacity cars and 100,000-lb. capacity cars amounts to 175%. The increase in the weight of rails used when 24,000-lb. capacity cars were in service, as compared with the standard rail used to-day amounts to 100%. The guarantee of wheels as between that given 15 years ago and that given to-day has increased 100%, while the increase in the weight of wheels used under 24,000-lb. capacity cars and those used under 100,000-lb. capacity cars has amounted to about 25%.

The number of wheels per car being the same under a 50-ton car as under a 12-ton car, and the increase in load being 333⅓%, and the increase in guarantee being 100%, there is a demand for increased efficiency in cast-iron car wheels of 433⅓%. If the added tare weight of the 50-ton car over the 12-ton car is considered, it can be reasonably estimated that there is a demand for a 500% increase in the service of car wheels to-day over the service demand which existed not over 15 or 20 years ago. It is only natural for anyone to ask why the weights of the wheels have not been increased in proportion to the weights of the other equipment, such as rails and axles. One answer which I can make to this question is that the cast-iron wheel has been giving such satisfactory service under the old style of equipment that it was thought that it was sufficiently strong to carry over twice, and sometimes three times the load which it has been carrying. This, however, has been found to be wrong, and the tendency of the times is towards a heavier wheel for heavy capacity cars, and it looks very much as though a 700-lb. 33-in. wheel would be considered standard for cars of from 80,000-lb. to 100,000-lb. carrying capacity.

DEVICE FOR TAKING UP SLACK IN AUTOMATIC COUPLERS.

In the article on "The Improvement of Car Couplers and Draft Rigging," in our issue of Jan. 30, reference was made to a device now being tried on the Chicago, Rock Island & Pacific Ry. for taking up the slack between couplers, by means of rings inserted in the link slots of the knuckles. This is the invention of Mr. W. F. Gould, 1520 W. Locust St., Des Moines, Ia., from whom we have recently received photographs of the device. The accompanying cut shows a tender coupler fitted with the device; the ring, A, has made 30,000 miles and is still in use on engine No. 255. The rings on the coaches and baggage cars have made 25,000 miles and the knuckles are not yet worn out; in fact we are informed that they have not worn since the [illegible] were applied, the rings taking all the wear, being still in good serviceable condition. The rings are 3⅛ ins. diameter and 2 ins. high.



Tender Coupler with Ring for Taking up Slack.
W. F. Gould, Des Moines, Ia., Inventor.

the edges beveled to prevent them from catching. As the diameter is ⅛-in. greater than that of the knuckle, the two together will take up ¼-in. slack with new couplers, or more than this with worn couplers.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

The third annual convention of this association was held March 18, 19 and 20 at the Auditorium Hotel, Chicago. It was well attended and the work done promised well for the future development of the association, but it is evident that the Board of Direction will have some difficulty in getting its committees and their members to work to the best advantage. This subject was discussed at one of the sessions, and numerous suggestions were made, including the issue of a monthly publication for obtaining and disseminating information. Of the 15 standing committees, only two failed to present reports: those on "Water Service" and "Uniform Rules and Organization." The 13 reports presented by the other committees were of varying character and quality. A good plan followed at all the meetings was that each committee, when its report (printed in advance) was presented, assembled at a table beside the President, so that it could be addressed directly in the discussion, while it also served to familiarize the members at large with those on the committees. An amendement to the constitution was adopted limiting discussion to members or to persons specially invited to speak.

The first session was called to order about 10 a. m., March 18, and the annual address was delivered by the President, Mr. George W. Kittredge, Chief Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry. Some extracts from the address are given as follows:

Your directors have held frequent meetings during the past year, which have been reasonably well attended. They have tried to keep in touch with the work of the various committees, and have tried to get reports formulated in such a manner that only such branches or portions of subjects should be handled as could be fully considered and carried to definite conclusions, although some reports must of necessity be reports of progress. Efforts have been made to have the reports so handled that they shall be truly the reports of committees and not of individuals.

It is encouraging to feel that the higher executive officers of the railways look with favor upon our organization, and with interest upon our meetings, discussions and publications. In these days of accelerated time, of necessities for better and smoother riding track, of increased weights of motive power and rolling stock, each and all of which means directly or indirectly increased expenses in maintenance, a great opportunity is open for the association to demonstrate its value by setting forth and endorsing methods that are effective, and at the same time provide for the safe, expeditious and economical handling of the traffic.

The reports of the Secretary (L. C. Fritch, B. & O. S. W. Ry.), and the Treasurer (W. S. Dawley, C. & E. I. R. R.) were then presented, and showed the following conditions as to membership and finance:

Membership, March, 1901	359
Members admitted during the year	60
Members lost during the year (deaths, 4; resignations, 3; dropped, 6)	13
Membership, March, 1902	406
Balance cash on hand, March, 1901	$2,117
Receipts during the year	$6,290
Expenditures during the year	$6,030
Balance cash on hand, March, 1902	$2,377

The members lost by death during the year were J. F. Kidder, J. T. Mahl, G. A. Quinlan and J. W. Taylor.

After this part of the business had been transacted, the committee reports were presented. We have given abstracts of nearly all these in last week's issue and elsewhere in the present issue. The following are general notes of the reports and the discussions:

*City Engineer, Baraboo, Wis.

†Extract from an address before the engineering students of Purdue University.

‡Griffin Wheel Co., Chicago.

ROADWAY.

The report of the Committee on Roadway opened with a discussion of the question of forms of cross-section for the roadbed or subgrade, recommending a width of 20 ft. at top of banks for single track and 13 to 14 ft. additional for double track; for less important lines, 18 and 16 ft. respectively. The committee also departed from common practice in recommending a uniform width for both banks and cuts, as follows:

In the theory upon which the width of embankments at subgrade is based, it is considered that the track in cuttings is placed upon what is virtually a low embankment, and in order to preserve uniformity of conditions immediately under the track throughout the line, the width of subgrade in cutting should be made the same as on embankments, outside of which sufficient room must be allowed for side ditches.

The greater part of this report, however, was devoted to the important question of the improvement of grades and alinement, which was discussed from both a practical and a theoretical point of view. This part of the report is reprinted nearly in full on another page. The discussion turned mainly on the width of roadway and the fact that as much of the railway work of the present time is the rebuilding and improvement of existing lines the question of maintenance is of more importance than economy in cost of construction. It was suggested that new banks should be of such width as to leave the standard top width after the slopes have slipped and weathered before the bank becomes consolidated. There was also some discussion as to the amount of load on cars which can be plowed off by a locomotive or unloader, and it was shown that with modern large capacity cars (25 to 30 cu. yds.), it is often impossible to haul the plow over the cars with a small or moderate-sized locomotive.

TRACK.

The Committee on Track then presented its report, an abstract of which is given elsewhere. After discussing the questions of easement curves, curve elevation, and vertical curves, the report took up the proper methods of tamping and spiking; it described exactly how each particular kind of ballast should be tamped, and how spikes should be driven. Considerable time was taken up by a rather scattering discussion, but when it came to solemnly adopting recommendations as to tamping and spiking, Mr. C. S. Churchill (Norfolk & Western R. R.) entered a protest. He thought it a waste of time as no member of the association would think of following all the recommendations, and it was not wise to go on record as officially adopting such recommendations, especially as members had not had time to consider the report carefully. The voting on the recommendations had been proceeding listlessly, few members taking the trouble to vote either way, but Mr. Churchill's remarks put a little energy into the proceedings and after some discussion it was voted to simply accept the report, and to request members to carry on the discussion with the committee so that it might present a report in better form at the next annual convention. In the earlier part of the discussion, the committee's recommendation of 7 ins. as the maximum for curve superelevation was changed to 8 ins. The discussion on this report occupied part of both the morning and afternoon sessions.

TIES.

The Committee on Ties presented a good progress report, dealing mainly with the questions of timber supply, preservative methods and statistics. An abstract of this report was given in our issue of March 20. The forms of tabular blanks for records, submitted by the committee, were adopted with a few changes; one of these provided for special mention of bridge ties, and another changed the ton-mileage record to tonnage, since it is the tonnage which passes over the track that affects the wear of both ties and rails.

After this report had been disposed of, Mr. Herman von Schrenck, special agent of the Bureau of Forestry, U. S. Department of Agriculture, gave a brief address on the work undertaken by the Bureau for watching and recording the results of treated ties in the track. He also gave some particulars of his visit to Europe last year to investigate the question of timber preservation.

SIGNALS AND INTERLOCKING.

This committee did not get to work until February, and modestly presented but a very brief report, an example which might have been followed to advantage by some of the other committees whose work was delayed until the last minute. The report in question dealt with the standardizing of castings for semaphore arms, and it was voted that the committee should send out a letter ballot to get the opinion of the association as to the continuous-light principle, and the proper travel of the semaphore arm. The following is an extract from the report:

On the subject of standard designs and specifications for interlocking plants, the association's opinion was asked at the last meeting about the desirability and practicability of adopting a single-type or fixed signal for all interlocking and block purposes.

We present the question again for your consideration. In respect to its desirability we have this to say: Over 100 designs of semaphore castings are now on the market and in use, many of which are bad and do not embody correct principles. The good ones differ in unimportant details. It has been customary to consider a different design necessary for different degrees of travel of the signal arm and light casting. We propose a standard form of casting adapted to the three-position signal, the two-position signal with 90°, 70° or 60° travel, the only difference being that a separate spectacle is required for each. The castings are side bearings, but they are equally well adapted to the side bearing or the center bearing. The only change required is the lamp bracket.

BALLASTING.

The brief report of the Committee on Ballasting was the first to be presented at the morning meeting on Wednesday, March 19. An abstract of this was given in our last issue. The discussion turned mainly on the advantages and cost of burnt clay ballast and the advisability of screening gravel ballast, but a proposition to require the screening of gravel containing more than 30% of sand was voted down. Attention was called to the fact that the word gravel is extremely vague and conveys no idea as to the proper size of the particles or the proportions of stone to sand and fine material. The report stated that the subgrade should drain freely, but it was pointed out that as a matter of fact the best roadbed would be impervious, so as to shed the water draining through the ballast. A proposal to change the minimum depth of stone ballast from 8 ins. to 12 ins. was rejected, but it was voted to change the cross-section for stone so that instead of sloping directly from the top of the ends of the ties it should be shouldered out horizontally 8 ins. beyond the ties.

BUILDINGS.

This committee, which presented no report last year, now had a report on coaling stations and water tanks. It was prepared mainly by the familiar method of sending out circulars of enquiry and embodying the replies in the report. The circulars were sent to 225 railways, but only 43 replies were received, and the general indication was that little care was taken in filling out the blanks. The discussion turned mainly on the weighing and measuring of coal, some members considering that the amount in each pocket should be weighed, while others thought it better to measure the quantity by calibrating the tender. Prof. C. F. Allen remarked that enginemen take more interest in their coal records when they know that a reliable system of weighing is in force, and Mr. Kittredge (C., C., C. & St. L. Ry.) thought that if accurate information as to engine performance is desired it is absolutely essential to know exactly the weight of coal consumed. Prof. Allen also pointed out that the delivery of coal to the pockets by an elevator and the incline dispensed with there is a saving of space which will be very valuable in a large yard.

SIGNS, FENCES, CROSSINGS, ETC.

This report was not approved by many of the members of the committee. The subjects selected were highway crossing construction and protection, but the report was very sharply criticised, and it was eventually voted to refer it back to the committee for revision on the lines suggested by the discussion.

RAILS.

The report of the Committee on Rails showed that a large percentage of the output of the rail mills conforms to the Am. Soc. C. E. sections, and presented a suggested form of specifications, which latter, however, were modified in several details during the discussion. Mr. Trimble (Penna. Lines) explained that the specifications would apply to both Bessemer and open-hearth steel, and remarked that he had in use some open-hearth rails which conformed very closely to the carbon and phosphorus requirements of the specifications. The specified limits of shrinkage allowance were struck out, blanks being left for the insertion of the allowance at each mill. The variation in height was changed from 1-64-in. above and 1-32-in. below the specified height to 1-64-in. either way, and a variation of 1-16-in. in width of base was added. It was pointed out that the width of base is specially important where tie-plates are used, in order to get the correct fit of the spike holes. Prof. J. B. Johnson (University of Wisconsin) thought some scientific investigation should be made as to shrinkage. One member spoke of getting rails whose ends were not in a vertical plane (the head being longer than the base), and Mr. Webster (Philadelphia) spoke in favor of sawing the rails cold, or else facing the ends, as is done in Europe.

IRON AND STEEL STRUCTURES.

This committee worked by dividing certain subjects among sub-committees, only two of which had reports. The first part of the report, discussing the general practice in placing railway bridge work under contract, was passed with but little comment, but there was some discussion on the proposed specifications for rolled steel, and it appeared that there was a difference of opinion among the members of the committee as to certain parts of these specifications. One of the important points discussed was in regard to the respective merits of single-grade or double-grade requirements for range of ultimate strength. For the benefit of the committee a vote was taken on this point, but this was simply a small vote of members present and not representative of any action on the part of the association. This resulted as follows: (1) One grade of 55,000 to 65,000 lbs., 6 votes; (2) two grades, above and below 60,000 lbs., respectively, 15 votes; (3) one grade of 60,000 to 70,000 lbs., 10 votes; (4) one grade of 60,000 to 70,000 lbs. without reaming, none. Mr. T. W. Schaub preferred one grade (exclusive of rivet steel). Mr. Webster remarked that steel below 60,000 lbs. is generally used without reaming, while that above 60,000 lbs. is frequently reamed. Mr. T. L. Condron spoke in favor of the double-grade plan, as ensuring better results for the particular knid of work in which either grade is to be used, and he also strongly advocated reaming, except for unimportant details. The specifications should recommend first-class practice for bridge work, but punching without reaming is not first-class practice. The additional cost for reaming is but 4%, and this is for shop work only; the erection cost is slightly reduced and the cost of handling, freight, etc., is not affected. The report was accepted as a report of progress, with the suggestion that written discussions be submitted to the committee during the year.

YARDS AND TERMINALS.

At the morning session on March 20 the first committee called was the Committee on Yards and Terminals, which had presented a carefully prepared report dealing with the principal features to be observed in the design of repair and car-cleaning yards, district and division terminal yards and freight houses. The committee was complimented by the President upon its methods of work and the completeness and systematic character of the report. There was a brief discussion, relating mainly to the use of platforms at freight houses, to avoid the necessity of spotting cars into exact position opposite doorways. The report and its recommendations were adopted.

WOODEN BRIDGES AND TRESTLES.

This report was of an unsatisfactory character. It consisted of a short paper by the chairman and plans prepared by a sub-committee for a pile and frame trestle, but these plans did not meet the approval of the main committee. It was eventually accepted as a report of progress and referred back to the committee.

MASONRY.

The Committee on Masonry presented a report accompanied by specifications, which led to considerable discussion. Mr. J. H. Abbott (B. & O. R. R.) objected to permitting mortar to be used within one hour after mixing. He instanced experience at the Henderson bridge with Louisville natural cement, where no mortar was allowed to be used after standing for 20 minutes. The specifications were amended so as to provide that mortar must be used before it has commenced to set. Mr. Taylor (St. L. & S. F. Ry.) thought the use of large stone should be permitted in the concrete backing for first-class masonry. In regard to a second-class Portland cement concrete of 1 to 4 to 8, he preferred proportions of 1 to 3 to 10, on the ground that it is better to lower the quality of the concrete by a smaller proportion of mortar to stone than by a smaller proportion of cement to sand. Mr. Raymer pointed out that a difficulty in applying general specifications to practice is the great variation in the quality of the sand and gravel available for use in different places. Mr. Atwood (P. & L. E. R. R.) said that for this reason and on account of the different kinds of work in which concrete is used, it would not be advisable to recommend general specifications. The discussion also turned on the relative proportion of voids in different kinds of sand, and Prof. J. B. Johnson pointed out that the function of the cement is not only to fill the voids, but more especially to coat every particle of the sand.

RECORDS, REPORTS AND ACCOUNTS.

The report of this committee was not ready for distribution until the last session of the convention. As it was quite lengthy and accompanied by numerous blank forms suggested for use in keeping records, the members were not well prepared to discuss it. In the distribution of cost of maintenance work it was thought that while the classification of the Interstate Commerce Commission (which the committee followed) was good in general, yet its subdivision was unsatisfactory. For instance, rail renewals and tie renewals include only the cost of the rails and ties, while the labor of renewing them is included under the general head of repairs to roadway. Mr. Abbott (B. & O. R. R.) thought that in this matter the Auditing Department must be taken into account, and should co-operate with the Maintenance-of-Way Department in order to devise a uniform system of accounting which would be satisfactory to both departments.

ENTERTAINMENTS AND EXHIBITS.

The annual banquet was held March 19, but the Board of Direction wisely decided not to accept any invitations for excursions of the association as a body, as in view of the number of reports it was not advisable to shorten the time available for the business proceedings. Before the close of the convention a vote of thanks was tendered to the Committee of Arrangements for the manner in which it had performed its duties in regard to both the technical and the social features of the convention.

In accordance with the practice of this association, supply firms were permitted to arrange for exhibits, but not in the room for the meetings, and the hotel parlor was well filled with exhibits. A list of the exhibitors is given in our Construction News supplement.

OFFICERS.

The announcement of the result of the election of officers for 1902 was made at the close of the convention.

and the full list of officers is given below: President, G. W. Kittredge, Chief Engineer Cleveland, Cincinnati, Chicago & St. Louis Ry; First Vice-President, A. W. Sullivan, Assistant Second Vice-President Illinois Central R. R.; Second Vice-President, Hunter McDonald, Chief Engineer Nashville, Chattanooga & St. Louis Ry.; Secretary, L. C. Fritch, Division Superintendent Baltimore & Ohio Southwestern R. R.; Treasurer, W. S. Dawley, Chief Engineer Chicago & Eastern Illinois R. R.; Directors, F. H. McGuigan, General Superintendent Grand Trunk Ry.; A. W. Johnston, General Superintendent New York, Chicago & St. Louis Ry.; J. Kruttschnitt, Vice-President and General Manager Southern Pacific Ry.; T. F. Whittlesey, General Manager Toledo Terminal Ry.; A. Torrey, Chief Engineer Michigan Central R. R.; Thomas Rodd, Chief Engineer Pennsylvania Lines West of Pittsburg.

ECONOMICAL METHODS OF ROAD IMPROVEMENT IN THE SOUTH.

By Chas. H. Scott,* C. E.

While enjoying a vacation a few years ago, the writer was for a short time employed as Supervisor of Public Roads for Warren Co., N. C. A road law specially enacted for the county had abolished entirely the old plan of "calling out the hands" to do free work on the roads, substituting therefor a tax on poll and property. This tax was very small, netting not quite $4,000 per annum during the two years of my service. There were about 360 miles of roads to be cared for in a territory of about 500 sq. miles Of this mileage a considerable percentage, of course, was not much used. Of the main roads, some parts, lying on sandy or gravelly surface, were never very bad. A large part of these roads, however, lay on a surface which was either wholly composed of clay, red or yellow, or of clay covered with a thin layer of light sandy loam which when not drained was easily cut through or washed off, exposing the clay.

These parts of the roads in winter and in wet weather generally became unspeakably bad, the clay cutting up to a depth of from 1 to 2 feet, and some stretches of road becoming wholly impassable.

The very limited money available for road work led to a careful study of the conditions of the case, with the following results:

It was observed that many parts of the roads which were always good had a surface covering of sand or gravel, often very thin, covering clays, red or yellow, beneath. Careful examination of the thickness and nature of this covering and its relation to the underlying clay disclosed several interesting and important facts.

It was found that the covering of sand, gravel, or sandy loam was often very thin, on sections of road that were hardly ever cut up or in bad order. In some cases, in which there was no noticeable deterioration of the roadway in seasons that were quite unfavorable, the sandy covering was not over an inch thick over a yellow and rather porous clay. It was also noted that an ordinary sandy loam, or "soil," as it was commonly called, often made as good a covering as any other—the varying fineness of its materials causing a closer packing. This appeared to make it superior to a fine sand of uniform grain, which was more apt to cut up when dry.

Many parts of the roadway had alternate sections of denuded clay and of sand or gravel surface, while others in which the clay was more generally exposed, had sand, or gravel, or sandy soil, nearby. It was determined to try the plan of shaping up the clayey parts of the roads into a good surface, either by hand or machine, and then covering the roadway with the best materials procurable, by the use of wheel scrapers. This plan proved signally successful.

Parts of the roadway thus repaired, which had been for years notoriously bad, and almost impassable during winter and wet seasons, have been so entirely changed in character that a team may be driven over them at a trot any day in the year. The material, when properly selected and applied, has compacted into a firm, hard surface, which sheds water freely and rapidly, is dry soon after rainfalls, and is scarcely ever cut to any appreciable depth, and often hardly marked by the passage of vehicles even when heavily loaded.

The writer has recently visited and inspected some points at which this work was done four or five years ago, and found them still in admirable order, while he is assured by those in a position to know that only a very trifling amount of money has been expended on them in the interval of time mentioned. The results have been surprising even to the writer, although he hoped much for the work. Of the estimate placed on it by citizens generally, the accompanying letters* from an ex-county commissioner who has always taken a deep interest in such matters, and from a reputable physician, who has frequent occasion to pass to and fro over the work, will testify.

ROADWAY CROSS-SECTIONS AND MODE OF APPLYING COVERING.

In Fig. 1, the lower line shows the shape which was given to the original clay roadbed. The rise in the center is made as light as will secure drainage,

Fig. 1.

so that the greater rise necessarily given to the covering will not cause it to wash off in heavy rains.

The covering is put on to a depth of from 3 to 5 ins., when packed; of fairly uniform thickness, for a width of about 8 ft., thence tapering out to nothing in 2 or 3 ft. more; though sometimes under favorable circumstances, and on more used roads a little wider. Fig. 2 shows another section where the old road is wider. The dimensions of the improved part are the same as in Fig. 1, the unimproved part being shaped up and left for passing. In Fig. 1, the road is in a narrow cut, such as is often found on our older roads; the cuts being gradually made by washing, and often being 10, 15, and even 20 ft. deep. Passing in these narrow places is often difficult and sometimes impossible, one team having to turn out at a wider point and wait for the other. The clay in these

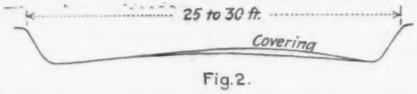


Fig. 2.

places, even where the hills are steep and drainage good, from its affinity for water and its ability to hold it like a cup, in every accidental abrasion or depression, becomes gradually cut up to a depth of from 1 to 2 ft. The wear and tear on teams and vehicles becomes worse and worse until "turnouts" are resorted to, the roadway being temporarily diverted into the fields or woods alongside. Friction and contention with adjacent landowners result. Sometimes a new roadway is bought, and the old one is finally abandoned. This is frequently the best way out of the difficulty.

Merely shaping up a roadway in red or yellow clay, by machinery or hand, does little good, and the money is largely thrown away. The affinity of clay for water and its ability to retain it in every depression, easily made by animals and wheels when the clay is soft, causes it soon to cut up to indefinite depths. One of the worst pieces of road the writer has ever seen was a place in which the section was as shown in Fig. 3. It was in a clay varying from red to yellow and very soft. A natural drain, 3 or 4 ft. deep, had been formed on each side by washing, and the roadway between was barely wide enough for single vehicles, and sloped naturally to either side when dry. It was on a hill, too. Yet, notwithstanding this apparently excellent drainage, this place got up in wet weather so as to become nearly or quite impassable, and wrecks were strewn along its sides.

A sandy loam will often make a good covering when the proportion of sand is heavy. A mixture

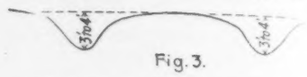


Fig. 3.

of fine and coarse sand with a little gravel is excellent. A small amount of clay with the gravel and sand not only does no harm, but by compacting and cementing the other materials forms a surface that sheds water perfectly, and resists abrasion or depression. The use of gravel, especially coarse gravel, is strongly objected to further north, where frosts are heavy, because of its holding water in the form of ice and snow, and becoming cut up in the thaws of late winter and early spring. I have especially noted the objections of the Supervisor of Roads in Ontario, Canada, to gravel, on this account. This objection does not apply in the South, where frost does not penetrate so deep, and the ground dries out more rapidly.

COST OF THE WORK.

The actual cost of the work, even when done under some drawbacks, has been remarkably small. With a gang of only two or three scrapers it has ranged from 12½ to 15 cts. per lineal yd. of road, with a haul of about 400 yds. over a rather rough road, from a gravel pit off the road. Only the common teams of the country were used, although they were light for such work, and inexperienced men handled the scrapers. The gravel at the pit was plowed, and no snatch team was used in loading, making the loads a little light on the average.

With a larger gang of scrapers, say from four to six, the latter being probably the best number, and with experienced hands, the cost could be reduced. With the larger gang of scrapers, a snatch team could be profitably used, and the loads increased. The loaded scrapers passing over the material already put out roll and pack it sufficiently. One man is kept on "the dump," or point of unloading, to spread and level off the material, with a common hoe.

The clayey surface of the roadway may be previously prepared either with a road machine—very preferably—or by hand. With a light gang of scrapers on a long haul, it has been found that the "man on the dump" could do the work fairly well, scraping the clay from side to center and letting the scrapers pack it by passing over it before turning, as they were unloaded. This was in one of the lighter micaceous clays, in a rather damp condition. In the tougher clays, and in dry weather, more labor would be required.

The cost, as shown, ranges from $220.00 to $265.00 per mile of improved part of road, and as these improved parts are often detached, and alternate with others not needing improvement, except ditching, the cost of making a uniformly good road of a very bad and often almost impassable one, is thus reduced to $125.00 to $150.00 per mile, in many instances.

This is no fancy sketch, but is based on work actually done, the results of which are there to stay and to be seen.

This ought to encourage the poorest and feeblest communities, in which the physical conditions are at all similar to ours, to undertake the work of road improvement. It is not contended that the plan presented is adapted to all parts of the country; but it is thought that it is well adapted to a great part of the South, including the southern and eastern parts of Virginia, the Carolinas, Georgia, Tennessee, Arkansas, and the states further south.

The wheel scraper plays an important part in the work. No. 2 scrapers are generally best for the purpose. These can be bought for a moderate amount, and worked either by teams bought and kept for the purpose, or "hired in" from the surrounding country; or by a combination of the two, some being regularly kept and others hired.

*Box 201, Elkins, W. Va.

*I am thoroughly convinced after five or six years observation of the red hills graveled under your direction while Superintendent of Roads of Warren county that it is by far the best and cheapest method that can be adopted with a limited amount of money. The hills on which you had gravel placed five or six years ago are now as good as or better than when the work was first done, and in many cases are now the best part of the road.
Warrenton, N. C., Nov. 27, 1901.

Your road work still remains in almost as good condition as when first done and in the meantime has required very little repair. Only once has it been necessary to fill in a few ruts and breaks or washouts on the side of the roadbed. I have often blessed you when driving at a brisk gait instead of tugging through the mud, a foot deep, at a snail's pace. The same system, I am glad to say, has been used at several points in the county, very much to the benefit of the roads and comfort of the traveling public. The cost is a mere trifle compared with the benefits derived, and when the gravel is obtainable it is the cheapest and best road for the expenditure.
Warrenton, N. C., Nov. 15, 1900.

A road machine is a desirable addition to the plant, and should be used where practicable; but where means are too small for it, good work can be often done without it. The writer earnestly hopes that others may be induced to give the plan presented a full and fair trial; and will be glad to give further information to those interested, and in a position to put it to practical use.

METHODS OF REDUCING THE COST OF CONTRACTORS' WORK ON ROAD CONSTRUCTION.

By Halbert Powers Gillette.*

In Engineering News of Sept. 5 and Sept. 19 last the writer gave some suggestions concerning methods which can be adopted by the engineer in charge to reduce the cost of macadam road construction. In the present article he wishes to set forth certain economies which the contractor for such work can adopt to reduce its cost.

In the first place, if a contractor is to work with reasonable economy he will require a considerable plant. A crusher, steam roller, sprinkler, quarry and grading tools will cost, let us say, about $7,000. This plant should evidently be kept busy as many hours in the day as possible, to reduce the fixed charges per cubic yard of macadam laid. To this end two eight-hour shifts should be worked. The cost of artificial light to enable this to be done is nominal, except toward the end of the season.

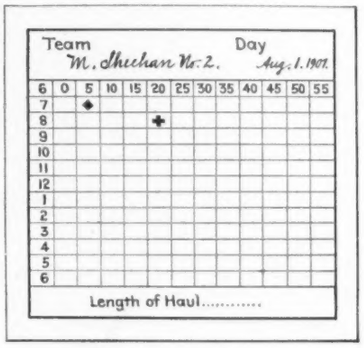
A crusher should not be purchased until, after actual trial extending over several days, it has shown an output of at least 8 cu. yds. per hour. Few 9-in. × 16-in. crushers will be found up to this standard.

For supplying steam to the crusher-engine a large horizontal 20-HP. boiler on wheels should be used. It is false economy to employ a small 12-HP. boiler, for it cannot furnish steam enough to run the crusher right along at its full capacity. The engine should not be mounted upon the boiler, but should be entirely separate and bolted firmly to a well-made foundation; for the irregular action of crushing causes constant variation of speed in the engine; and even with a good governor, the engine may "run away" at times, and rack the boiler or loosen flues. The crusher should not be a light one with sheet steel sides, which sooner or later yield and cause undue wear of bearings; a substantial cast-iron or cast-steel frame is to be preferred. It is of doubtful advantage to have the crusher mounted on wheels; a heavy stone wagon with low trucks can be used to move the crusher, which should be seldom done, as the lost time of moving will more than counterbalance extra cost of hauling stone in most cases.

A pit should be dug in which to set the crusher, the excavated earth being so placed as to divert surface rain water; then cover the whole pit and crusher with a platform that will shed rain as well as receive the stone dumped. By placing the crusher in a pit, the crusher platform may be made low and thus render the ascent for horses and men easy.

The elevator which hoists the broken stone from the crusher to the screens usually causes more breakdowns than any other part of the plant. If a sprocket chain is used to drive the elevator, see that it is loose and not taut. The elevator which gives least trouble by breakdowns and clogging is an endless rubber belt. The only objection to it is that it cannot have a rise greater than about 1 in 2 or 2½, which necessitates considerable length of elevator. The cost of extra length is quickly made up, however, by saving in lost time.

The bins should be large and substantial, capable of holding at least 3 hours' crusher product. They should have bottoms sloping 1 to 1 and lined with sheet iron. The chutes may be small sheet iron affairs projecting from the face of the bin, and pivoted so that they can be raised after filling the wagon. Large, heavy wooden chutes or doors are difficult to handle and cause loss of time in loading. A wagon can be loaded by the driver in little more than 1½ minutes if bins and chutes are properly made. This is very important, for if it takes 6 minutes to load, which is not infrequent with flat-bottomed bins and heavy wooden chutes, and there are 10 teams to be loaded beginning in the morning, the last team will not get away until an hour after the first. To guard against wasted time, provide each teamster daily with a time card, such as shown, and give to a man in charge at the bins and to the man at the dump on the road, a conductor's punch, so that the time of departure at each end of the haul may be punched on the card. An average of 2½ miles an hour, or 220 ft. a minute on the trip



Team Time Card.

Note.—The diamond-shaped punch shows that the team started on its trip at 7.05. The cross-shaped punch shows that it started to return at 8.20.

should be maintained. I saved 25% in the cost of hauling alone by adopting the method described.

The crusher should not be located down in the quarry, but up where the teams will have no steep ascent for the heavy loads of crushed stone. The quarried stone can then be delivered in small one-horse dump carts, directly upon the crusher platform. In building the road, instead of beginning at the end of the road farthest from the crusher and working back toward the crusher, as is so often done and even specified,* begin nearest the crusher and work away from it; thus the teams haul over it right up to the section in process of construction, where for a short distance only they will have a hard pull over soft earth. A "snatch-horse" with a boy driver may be necessary to help the team this short distance. The advantage of this method is that instead of a load of only 1½ cu. yds., a team can haul 2½ or 3 cu. yds. of stone the whole distance. Even where the macadam consists of a course of 4 ins. of local stone and 2 ins. of trap, the teams may haul over the local stone as soon as it has been rolled, and it need not be picked up or "scratched" afterward to enable the two courses to bind together, as engineers seem to have supposed necessary. I have laid 2 ins. of trap directly upon a hard 4-in. course of limestone that had been traveled over for weeks; I rolled and bound the trap without scratching the lower course, and after two years the trap shows no signs of scaling off, as every one predicted it would. With one team I have hauled 4 cu. yds. of broken stone up a 5% grade, where it had been all a team could do to haul 1½ cu. yds. before the road was paved.

In dumping and spreading the stone, it is well to own about three or four patent dump wagons to be used on short hauls; but after the haul becomes a half a mile or more, the common slat-bottom wagons are just as economical. It will take a man to assist the driver in dumping; and 5 minutes may be allowed per load, which gives the team a little needed rest on long hauls. Each load may be dumped in 3 piles, the dump man being instructed as to the number of loads to be dumped per station. At intervals of two or three hours hitch one of the sprinkler teams to a Stuart grader, and in a few minutes the blade of the grader will spread it quite well, so that the dump man using a potato hook may quickly complete the spreading. With team and driver at 35 cts. and labor at 15 cts. an hour, the cost of spreading with the grader is 1 ct. a cu. yd., and completing the spreading with a potato hook costs another cent; total, 2 cts. a cu. yd. of loose material. The last N. Y. State Engineers' Report shows the actual cost to contractors to have been 10 or 12 cts. a cu. yd. for spreading done entirely by hand. This is somewhat higher than the writer's experience for hand-work, but it shows the possibility of a most decided saving.

In rolling use soft coal, as it is cheaper than anthracite, and see that the engineer runs the roller with the high-speed gear. If the water tank is too small to run four hours have it enlarged; for it should be filled only during meal hours. Provide a large pipe and hose from the sprinkler so that filling may be quickly done.

The water for sprinkling should be pumped up into a small stationary tank as near the level of the road as possible, a small gasoline engine serving well for this purpose, since it does not require an engineer. One contractor I know saved greatly in cost of hauling water for sprinkling by sinking small wells with a cheap borer at short intervals, from which by a gasoline engine he drew his supply of water. Nothing so greatly reduces the amount of rolling necessary as an abundance of water; for, instead of the slow method of jarring the screenings down into the voids with the roller, the water washes them in quickly if supplied in torrents. Take a short section of the road, say 100 ft. long, and go back and forth over it with the sprinkler until it is fairly flooded, then follow a few times over it with the roller to iron it out and the work is done. In the first place, of course, the loose stone must have been rolled until not easily displaced, even by a broad-tired wagon passing over it, before the screenings are spread; then spread the screenings with shovels, either from piles previously dumped alongside the road, or directly from a wagon driven over the as yet unbound macadam; then roll a few times and finally flood with water as above described. It is possible to puddle as described with 4 cu. ft. of water per cu. yd. of macadam. Some engineers compel the contractor to puddle and roll until no bare spot as large as the hand can be found. In this way, four or five times as much water as is really necessary may be consumed. These engineers forget that wagons were the only rollers, and the clouds the only sprinklers used by Macadam.

A good macadam pavement can be built in many ways; with little water or with much; with coarse stone or with fine; with screenings, and in some cases with none; but in every case there is some method that is more economical than the others, and the engineer should always have in mind, not alone the building of a good road, but a cheap road. I recall the reply that a "road expert" made when it was pointed out that a certain specification would add greatly to the cost. He said: "We are building good roads, and the State is going to get good roads no matter what they cost, so long as I have anything to say in the matter." I fear that such has been too often the policy of engineers employed by States and municipalities.

The sole criterion in road-building should be the sum of the cost of maintenance and interest on the investment. The engineer is never justified in designing a road wherein the aforesaid sum will be increased. Moreover, he should not merely guess that the increased interest cost is counterbalanced by reduced maintenance cost—he should base his estimate on actual experience; and if there is no record in dollars and cents, he will seldom err in adopting the cheapest form of construction. It is remarkable how durable some macadam roads are, when, according to all text-book writers, they should fail miserably.

*No. 791 Powers Block, Rochester, N. Y.

*The improvement shall be started at that end of the road furthest from the source of supply of the broken stone. (N. Y. State Specifications.)

CONCRETE-STEEL ARCH Y-BRIDGE AT ZANESVILLE, O.

The new bridge recently completed across the Muskingum and Licking rivers at Zanesville, O., is peculiar in that it is Y-shaped in plan. One arm, with three spans, extends from the east bank of the Muskingum River to a pier of triangular form fronting the mouth of the Licking River. From this pier two arms of three and two spans extend north and west to the banks of the Licking River.

This concrete-steel bridge is the fourth bridge built upon the same site. In 1812 the State legislature granted a charter to Moses Dillon and

others to build "a bridge across the Muskingum River opposite the foot of Main St. in Zanesville, and also a branch across the Licking River." This first bridge is said to have been an uncovered wooden structure, and to have failed after four years. In 1818-19 a new bridge was built under the direction of Mr. Wickham, an architect. The portion across the Muskingum had wooden trusses with stiffening arches and was covered. This bridge is said to have been condemned and taken down in 1830. A majority of the stock in the bridge company had been acquired by the firm of E. Buckingham & Co., and Mr. Buckingham soon commenced the construction of a third bridge. He was killed by the fall of one of the uncompleted spans, caused by a flood carrying away the falsework. This bridge, built in 1831-32, was a covered wooden bridge, with Burr trusses on sandstone piers, and was described and illustrated in our issues of Jan. 25 and Feb. 15, 1900. The old bridge was in continuous service for 68 years with but few repairs until nearly the close of its career, but when the running of electric cars over the structure was commenced (early in 1899) it began to show serious signs of deterioration. In December, 1899, the Osborn Engineering Co., of Cleveland, O., made an examination of the structure, and as a result of the dangerous weaknesses discovered the bridge was closed to traffic.

By special vote, taken according to law, Muskingum county was bonded to pay for a new bridge, and the Osborn Engineering Co. was retained by the County Commissioners to carry on the engineering work, and this company has furnished us with the following particulars as to the history and general construction of this new structure, which was noted in our issue of Nov. 28, 1901. A view of the new bridge, practically completed, is shown in Fig. 1, while Fig. 2 is a general drawing showing the span and size of the arches, etc.:

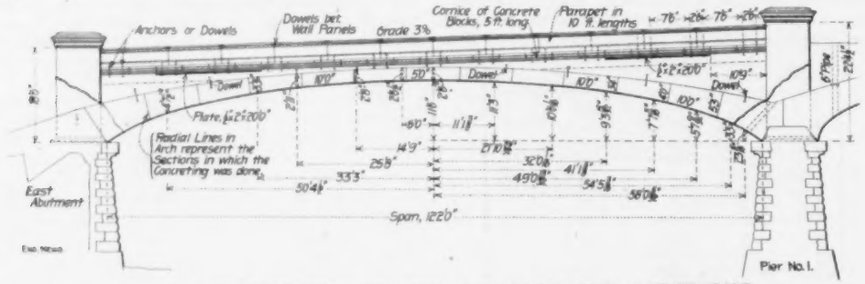

Anchors or Dowels
Dowels bet. Wall Panels
Grade 3%
Cornice of Concrete Blocks, 5 ft. long
Parapet in 10 ft. lengths
Dowel
Plate, 1/2 x 200"
Radial Lines in Arch represent the Sections in which the Concreting was done
East Abutment
Span, 122'0"
Pier No. 1.

FIG. 3. PROPORTIONS OF ARCH OF 122-FT. SPAN, 11.5-FT. RISE.

design was essentially the work of Mr. E. J. Landor, M. Am. Soc. C. E., at that time Engineer of the Wrought Iron Bridge Co., of Canton, O.

The arch curves adopted by Mr. Landor were flat ellipses, some of the arches being completely semi-elliptic and others segmental curves. The form of construction was the Thacher patent, consisting of concrete arch rings in which are embedded steel bars of about ¾ × 5 ins. cross-section, in which are driven rivets to increase the grip in the concrete, the steel bars being placed in two layers about 2 ins. from the intrados and the extrados of the arch ring respectively, and the bars of each layer about 3 ft. apart horizontally. The architectural details as submitted in the bid were drawn by an architect for Mr. Landor.

The bridge as constructed consists of three arms, located as nearly as practicable on the same site as the old structure, the east arm consisting of three spans, each 122 ft. in length, the west arm consisting of two spans, one 122 ft. in length and the other 99 ft., the north arm consisting of three spans about 81 ft. in length. The road[illegible] center of the bridge is about 6½ ft. higher t[illegible] the old structure. From this central point t[illegible] level on the east arm about half way, and th[illegible] at 3% to the abutment. There are two desc[illegible] dients on the west arm, the maximum being [illegible] north arm a 5% grade extends nearly the entir[illegible]

In constructing the bridge it was deemed bes[illegible] facility of construction and for appearance, to [illegible] architectural details materially, and the prese[illegible] ance of the structure is quite different from t[illegible] submitted by the contractors with their bid. T[illegible] is simple but massive and dignified in its ma[illegible] harmonizes very well with the surroundings.

The foundations for the piers rest on solid s[illegible] which has been found by actual core drill tests to extend for a depth of at least 25 ft. This rock surface is immediately on the bed of the river, there being practically no gravel, sand or other alluvial deposit on its surface. The river, moreover, at the ordinary stage, is only from 2 ft. to 4 ft. deep, and these conditions combined to make the problem of foundations an unusually simple one.

Work was actually commenced on the structure about October, 1900. During the fall and early winter foundations for four piers were constructed and the piers completed above ordinary high water level. The foundations of a fifth pier were attempted, but owing to extremely bad and unexpected conditions, practically no headway was made on it. During that winter and the early spring of 1901 not very much effective work could be accomplished on account of severe weather and high water, but about June 1, 1901, operations progressed more rapidly, and were then pushed steadily to completion.

In taking down the middle pier the remains of an older and smaller pier of earlier date were found inside and other evidences of earlier bridges were discovered in preparing foundations for the new piers.

In regard to the general design of the bridge, Mr. Landor, who is now with the Dominion Bridge & Iron Co., at Montreal, sends us the following communication:

The Osborn Co.'s general specifications for the work were modified or supplemented for the particular type of structure specified so as to include all the essential features of Mr. Edwin Thacher's specifications, as given in your issue of Sept. 21, 1899, which specifications were the real basis for the design. The stress diagrams were prepared by myself, ably assisted by Mr. F. E. Barnes, at that time one of my assistants as Engineer of the Wrought Iron Bridge Co., of Canton, O. The method used was that of Prof. Cain as given in his "Theory of Solid and Braced Elastic Arches" (Van Nostrand Science Series), modified in some slight particulars by methods given by Prof. Burr in his "Stresses in Bridges and Roofs;" in fact, the method used by Mr. Thacher in his various computations for similar work.

The limitations between waterway and grade line were so small that exceptionally shallow arches had to be used. With a view to fixing maximum waterway, elliptical contours were decided upon, but after examination it was found that only sections of semi-ellipses could be used in order not to curtail what we may perhaps term the effective depth or spring of the arch. Therefore, except for one or two spans adjacent to the Y pier, the major axis of the ellipse did not coincide with a line joining the spring lines on the pier, but was always below such a line. My recollection is that this distance was about 4½ ft.

The beautiful design that was submitted with the bid, as regards all but the number, lengths and rise of the

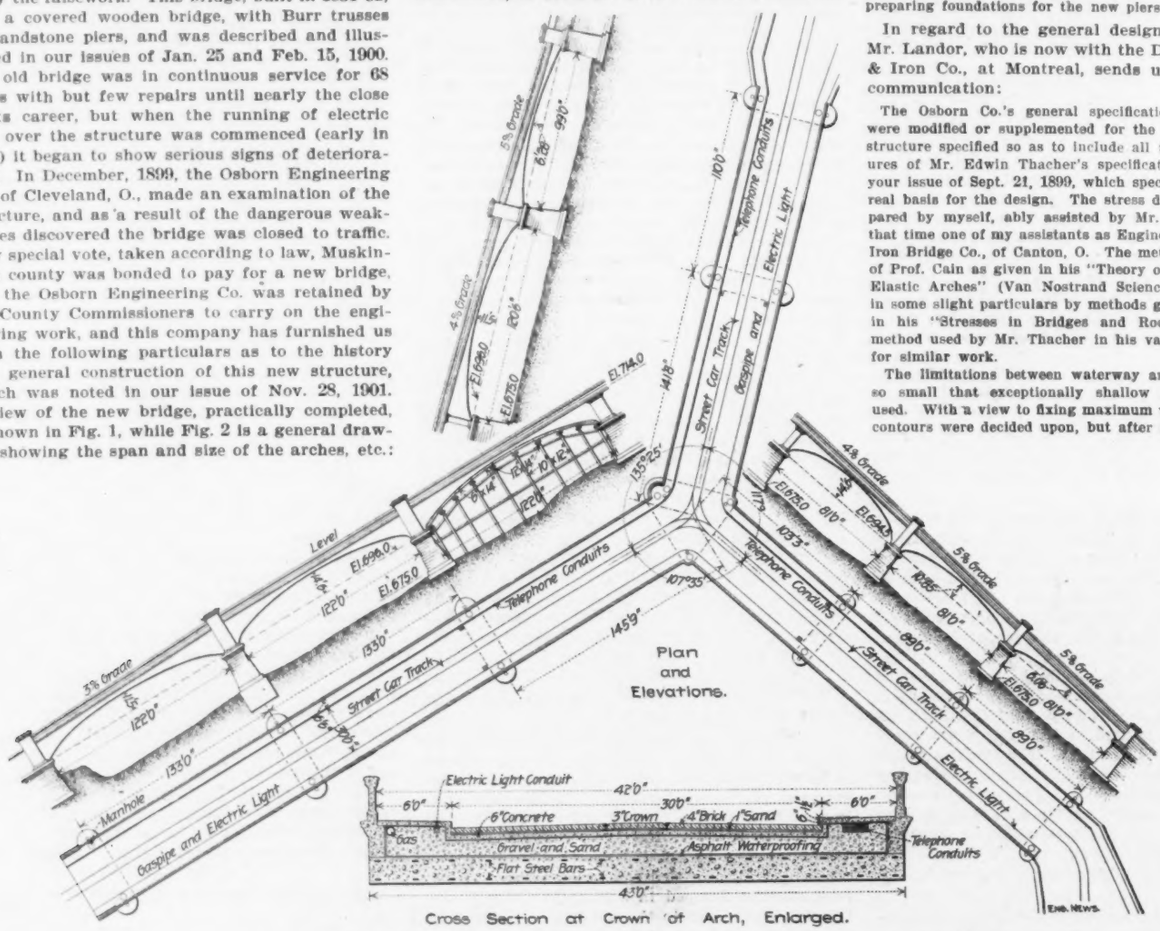


FIG. 2. PLAN, ELEVATION AND SECTION OF Y-BRIDGE AT ZANESVILLE, O.

architect, was supplied by Mr. R. Rosenstock, at that time with Hardway & Co., Architects, of Cleveland, O. Although in the construction wide departure was made from the features of Mr. Rosenstock's design, his design never-theless had much to do with creating popular sentiment in favor of the accepted bid for this bridge. Personally, I am sorry the special features of the design were not more closely adhered to in the construction.

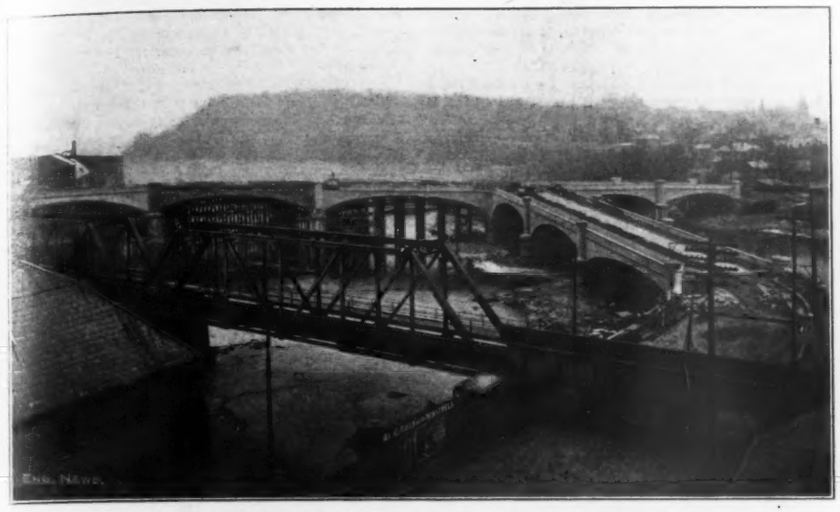


FIG. 1. GENERAL VIEW OF THE Y-BRIDGE AT ZANESVILLE, O.
F. J. Landor, M. Am. Soc. C. E., Designing Engineer; Montreal, Canada.
Osborn Engineering Co., Engineers for Muskingum County, Cleveland, O.
American Bridge Co., Contractors, New York, N. Y. Bates & Rogers, Subcontractors, Chicago, Ill.

After work had been commenced and some of the piers built, the American Bridge Co. came to the conclusion that it did not desire to undertake this class of work, and in August, 1901, the contract was sublet to the Bates & Rogers Construction Co., 1203 Manhattan Building, Chicago, which firm makes a specialty of concrete work. To the members of this firm we are indebted for photographs and for much information respecting the construction.

Although the number of spans is the same as in the old bridge, the lengths of the spans are not the same, so that the positions of the piers do not exactly coincide with those of the old bridge. The piers have a concrete core, with a facing of local sandstone. Those of the east and west arms are 11 ft. wide under the coping, while those of the north arm are 8 ft. wide. The center pier is tri-

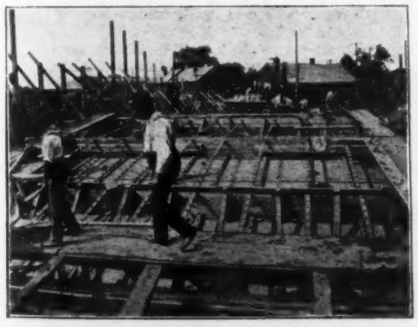


Fig. 5. Steel Bars in Position to be Embedded in Concrete Arch.

(Showing also the transverse bulkheads or forms separating the arch into sections for concreting. The planks on the face of the bulkheads are to form grooves for keying the arch sections together.)

angular, in order to form the skewbacks for the three arms. The arches are quite flat, as shown by the following table, and Fig. 3 shows the proportions of the east end arch, No. 1:

	Span, ft.	Rise, ft.		Span, ft.	Rise, ft.
Arch No. 1	122	11.5	Arch No. 5	99	6.28
Arch No. 2	122	14.6	Arch No. 6	81	14.6
Arch No. 3	122	14.6	Arch No. 7	81	10.85
Arch No. 4	120.6	11.5	Arch No. 8	81	6.06

The arches were built first and the spandrel walls later, the arches and spandrels being tied together with steel anchor rods or dowels, as shown in Figs. 3 and 4. The thickness at the crown of the arches ranges from 18 ins. for the 81-ft. arches to 30 ins. for those of 122-ft. span. The thickness increases towards the haunches. The spandrel walls, Fig. 4, are 15 ins. thick at the top, and increase in thickness toward the bottom, as shown in the section, Fig. 4. Each arch has 15 pairs of steel bars ¾-in. thick, and of varying width; 3 ins. for the 81-ft. span, 4½ ins. for others, and 5 ins. for the 122-ft. spans. The bars of each pair are about 2 ins. from the intrados and extrados, respectively, of the arch; and are not connected with each other. The bars are about 36 ins. apart c. to c., laterally. Each bar has rivets driven in it at 8 ins. pitch, to form a bond with the concrete, and the lengths are connected by double splice plates and six rivets. The bars of adjacent arches are made continuous over the piers, and the ends are simply embedded in the concrete skewbacks of the abutments and the center pier. These bars were supported by stakes and blocking during the depositing of the concrete, and are shown in position in Fig. 5.

The arch centers were of oak stringers 6 × 14 ins., and pine 8 × 14 ins.; these were laid on edge, 30 ins. apart, and supported by timber trestling, Fig. 6. On the centers was laid the lagging, consisting of Norway pine sticks, 2 × 4 ins., 2 × 6 ins. and 2 × 8 ins., dressed and matched. The forms for the spandrel walls were of tongued and grooved pine plank, planed and dressed, and carefully fitted. Fig. 7 shows the centering in place for one of the arches, with the form for the spandrel walls. It also shows one of the old piers and wooden spans in course of removal. The forms for the parapet walls were made in separate panels, which could be moved from place to place as required. The panels were 10 ft. long, joints being left between the 10-ft. lengths of the wall, and horizontal dowels inserted in the concrete to hold the lengths in line.

The arch concrete was composed of 1 part Portland cement to 2 parts of stone and 4 parts of sand. The cement was furnished by the Diamond Portland Cement Co., of Cleveland, O. A considerable amount of the concrete was made with a good quality of gravel which contained almost exactly the required proportions of stone and sand; broken stone or sand being added as required to maintain the required proportion of the constituents. A local stone was used, while the gravel and sand were brought from Trinway, O. The concrete in the piers and spandrels was mixed in proportions determined from time to time by the engineers. The materials for the arches were measured in boxes, and mixed in rotary tilting drum continuous mixing machines made by the T. L. Smith Co., of Milwaukee, Wis. (Eng. News, May 2, 1901). Two mixers were used, one of ½ cu. yd. capacity, driven by a steam engine; and the other of ⅓ cu. yd. capacity, driven by a gasoline engine, as shown in Fig. 8.

The concrete was mixed moderately wet, and conveyed to the work in wheelbarrows. The arches were built in transverse sections 10 ft. long and extending the full width of the arch, 43 ft. A plank 3 × 8 ins. was spiked against the outer end of the form of each section, leaving a groove to be filled by the fresh concrete of the next section, and so bonding the sections together. This is shown in Fig. 5. The lagging was covered with about 1 in. of cement mortar, and upon this the concrete was deposited, being rammed until water showed on the surface. The faces of the forms of the arch rings, walls, etc., were covered with a concrete made with fine broken stone, behind which was deposited the ordinary concrete, the stone being worked back by a spade. The concrete of the arches was allowed to set for 28 days before the centers were removed. No final treatment in the shape of plastering with cement or dressing with wire brushes to remove the marks of the forms has been done, but all exposed surfaces were worked with La Farge cement to bring them to a uniform color.

As shown in the cross-section in Fig. 2, the

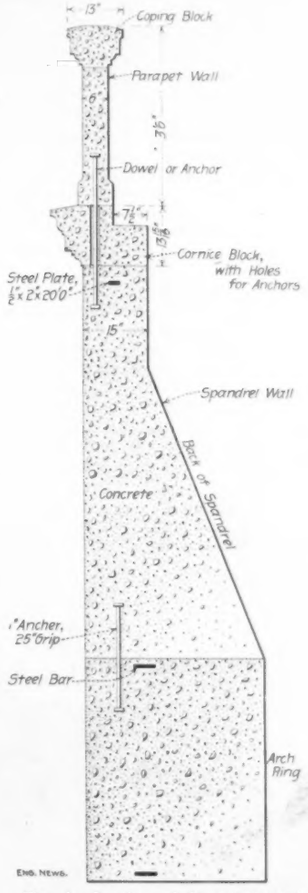


Fig. 4. Section of Spandrel Wall and Parapet.

bridge is 43 ft. wide over the arches, and 42 ft between the parapet walls, this width comprising a 30-ft. roadway and two 6-ft. sidewalks. The upper surface of the arch is coated with an asphalt waterproof composition, and the space between the arch and the spandrel walls is filled with sand and gravel, consolidated by flooding. In this filling are laid a gas main and electric light conduit under one sidewalk, and a telephone conduit under the other sidewalk. Under the roadway the filling is formed with a crown of 3 ins. and covered with 6 ins. of concrete. On this is a 1-in. cushion bed of sand for the 4-in. brick paving. The sidewalks are 6 ins. thick, with 4 ins.

of ordinary concrete, 1½ ins. of fine concrete and ½-in. mortar surface. A street railway track with 4-in. rails is laid in each roadway, the three tracks being connected by a Y on the center pier, and each track having its rails bolted to steel channel ties embedded in the concrete foundation. The parapet walls, 3 ft. 6 ins. high and 6 ins. thick, were

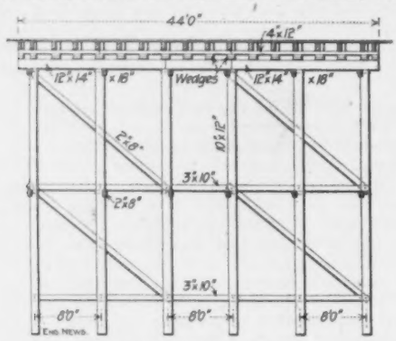


Fig. 6. Arch Centering.

built in place after the completion of the arches, vertical anchor bolts being left projecting from the upper surface of the spandrel walls to form a bond with the parapets. The cornice moldings, however, were made separately in blocks 5 ft. long, and set in place with mortar. Fig. 9 shows the setting of the cornice blocks, and the vertical anchor rods to secure these blocks and bond with the parapet wall to be built upon the blocks, as shown in Fig. 4. The holes around the rods are filled with cement. The parapets form recesses over the columns surmounting the center pier, and one of these recesses is fitted with a seat.

The last arch was completed in November, and the bridge was ready for traffic on Jan. 4, but the falsework and old masonry piers were not cleared away until the end of January.

In this connection mention may be made of a V-shaped bridge across the river Danube at Budapest, Hungary; the angle is very flat, and each arm consists of three iron deck spans with arch ribs. There is also an X-shaped bridge over the river Sarthe, at Mans, France, with spans of 10 to 55 ft., each consisting of a pair of plate girders 6 ft. apart. The bridge is about 13 ft. wide over the parapet walls, one arm carrying a steam tramway and the other an electric railway, the tracks intersecting over the center pier.

LOADING FREIGHT CARS TO THEIR FULL CAPACITY.

At the meeting of the Railway Transportation Association in Chicago, in January, one of the subjects discussed was the loading of freight cars to their full capacity. This subject had been assigned to a committee, which, however, had no report to present, but the chairman of the com-

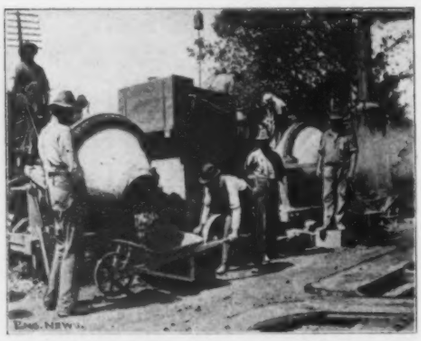


Fig. 8. Concrete Mixing Plant at the Zanesville Bridge.

mittee made a statement on the matter which showed some rather curious practices in car loading, and led to an interesting discussion, of which we give an abstract:

Mr. C. B. Adams (Wabash R. R.).—In following the light loading on the Wabash R. R., I have found that there is only one way to secure results, and that is by following very closely each individual car. The results so far are very gratifying, and our increased loading has repaid us for our trouble and expense many times over.

I have had cases where shippers at one point claimed that they could not load heavier, while shippers of the same commodity at other points were loading 5 and 10 tons heavier. With such evidence I find you can generally bring the other fellow up on his loading. There are several commodities that I know can be loaded heavier. Sugar is one of them; 100 barrels or 400 bags is considered, commercially, a carload of sugar. There is no good reason why 150 barrels or 600 bags should not be established as a carload. Shippers will tell you that they cannot load this amount, that the cooperage will not stand it; but it will, and we know that bags will stand tiering. The cooperage is not the trouble; they do not want to change the old custom, and as they are protected by the minimum fixed by the traffic associations, there is no object for the shipper to get out of the old rut. In consequence, we are running cars half loaded.

Glucose can be loaded 40,000 to 50,000 lbs. We followed up the light loading of this commodity and secured consent of one large concern to load 20 tons and over; in fact, they stated it would be agreeable to them to have the minimum raised to 20 tons.

The loading of flour can be considerably increased, both

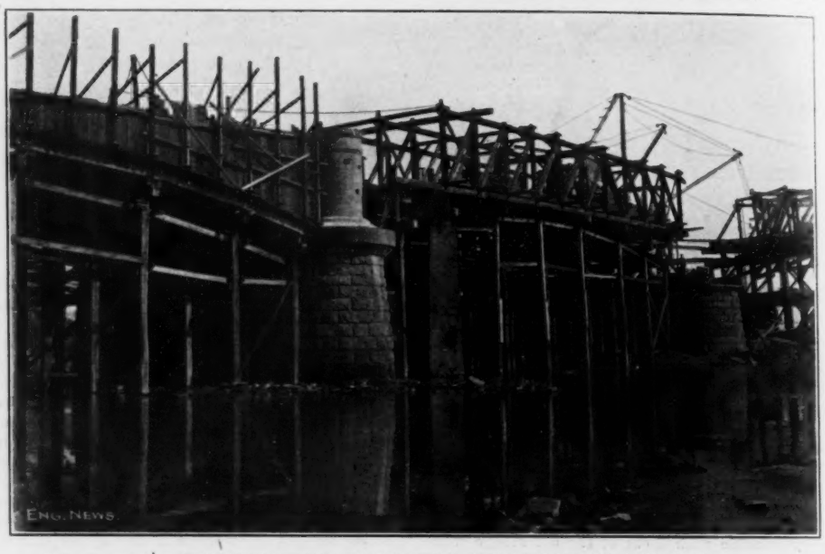


FIG. 7. ARCH CENTERING AND FORMS FOR ARCH RING AND SPANDREL.

barreled and bagged, except perhaps in paper sacks. We know that we can increase this loading, because we find in many cases it is loaded to capacity, and in some cases they want to load 35 tons. The question arises why all shipments of flour are not loaded to capacity? Because there is a low minimum; because there is an old custom that so many barrels or bags constitute a carload; receivers and distributors have been educated to so many packages in a car; their wareroom space or their trade takes just this number of packages, and the railways go on hauling half loads.

Grain shippers on our road have fallen into line, and are loading grain 10% above capacity. It is the exception rather than the rule when we find a car loaded below capacity; even oats are being loaded 30 tons in our standard cars.

If there is any commodity that can and should load to capacity it is brick and clay; yet I saw the other day a remonstrance from a number of large brick and clay concerns protesting against raising the minimum on these commodities. They still adhere to the old custom of 30,000 lbs.; half loads.

Railways have gone to an enormous expense in building heavy-capacity cars in order to be able to meet the reduced rates of transportation. Are we to stand back and see the money placed in large cars wasted and continue to permit hauling cars half loaded? I think not.

Mr. F. S. Rawlins (Kansas City Southern Ry.).—We find the most convenient blanks to keep track of loading are the daily reports made by the agents at the scale stations. The agent at each scale station makes a daily report to the auditor of all cars weighed. We have a report made to us, a duplicate of the report made to the auditor, with an additional column showing the capacity of the cars. So we inspect daily the weighing of all freight, which practically means all that is loaded. Then I take up each case of light loading at the station where it is loaded and see if we cannot improve upon it. In addition to that we make out a monthly report showing the number of cars of each commodity loaded at each station on the road, the total weights, and the average in tons per car of [illegible] modities loaded at each station. That we send our [illegible] superintendents and trainmasters, and we also [illegible] to the attention of the shippers as much as we can.

Mr. C. R. Gray (St. L. & S. F. Ry.).—I have [illegible] white lead. Somebody has explained that 32,700 lbs. [illegible] commercial carload. The patrons of a smelter on [illegible] will order a carload lot, and we will set a 60,000 [illegible] and an 80,000-lb. car in the plant and we will get [illegible] lbs. of load each. The only concession I have ever [illegible] able to get is, that if we will invariably furnish 80,000 [illegible] lb. cars when they have an order for two cars it will be placed in one.

Mr. D. Crombie (Pere Marquette R. R.).—There [illegible] element that interferes more with economical transportation and economical car service than classification. If [illegible] perceived more and more that arbitrary restriction as to what constitutes a carload interferes with our ability to load our cars heavily. During the car famines we have been experiencing of late we have been obliged to [illegible] two cars for about the cheapest commodity we handle when one car would have handled the load; in fact, we would have preferred to put that one car in use for some other freight. You cannot afford to antagonize an industry which is on your line. If they want that car to carry 100 barrels of flour, you have to give it to them. There is a trade term that makes a carload of beans 32,000 lbs., or 200 bags. A shipper in Michigan may have two carloads of beans to ship to the same consignee in St. Louis, yet they decline to load the two cars into one (although I can supply one car that will carry the double load), because the commission man in St. Louis wishes to dispose of it in single "carloads."

Mr. C. B. Adams (Wabash R. R.).—I think this association should take hold of the matter and by practical tests ascertain what the standard box car will carry. Let our experiments continue over a period of 60 days. Then we will be in position to go to the traffic officials and say, "Gentlemen, you should raise the minimum on these commodities; we are not asking for something impractical; here are the facts and figures; we have practically demonstrated what can be done."

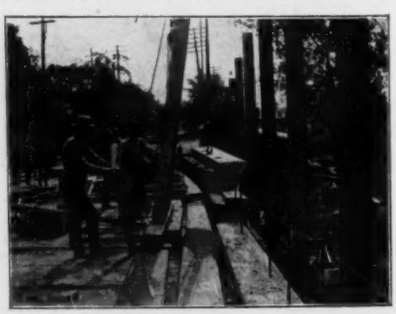


Fig. 9. Setting Concrete Cornice Blocks in Place.

Since the above was in type, the Official Classification Committee has announced increases in the minimum carload rates on grains and grain products, to take effect on April 1. The increase amounts to 5,000 lbs. or more in each case.